NATURE

A Weekly Journal of Science

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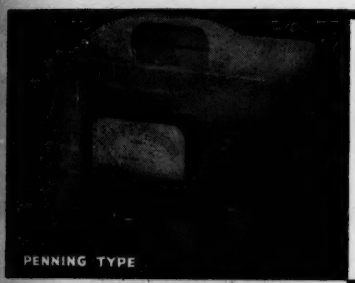

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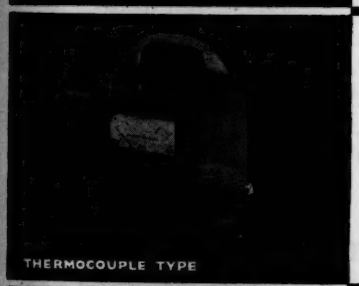

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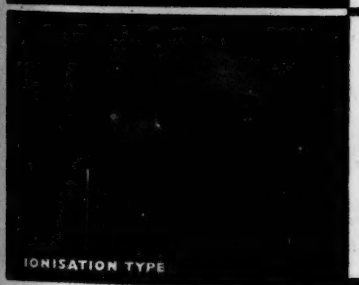

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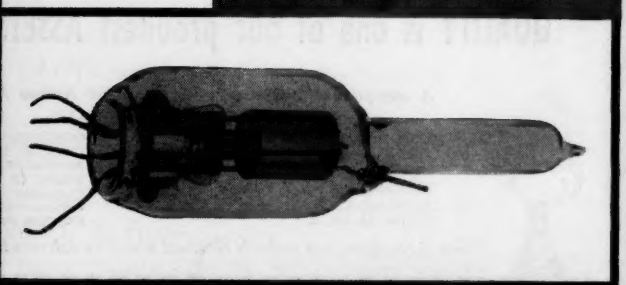

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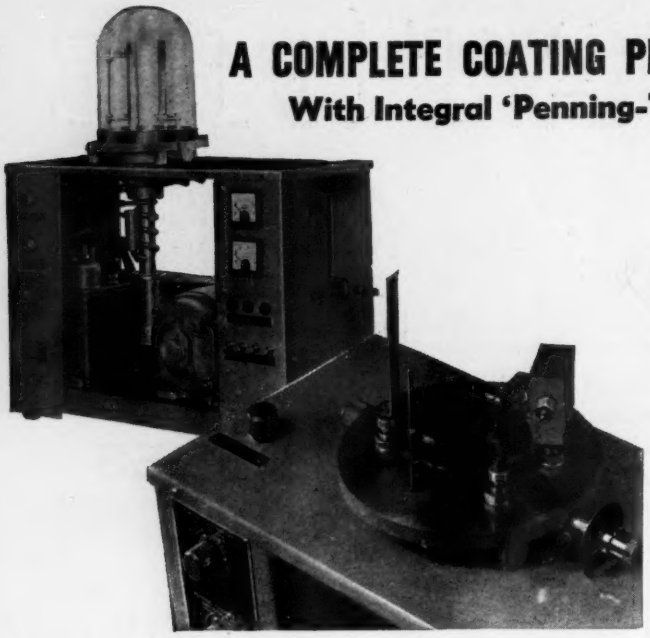

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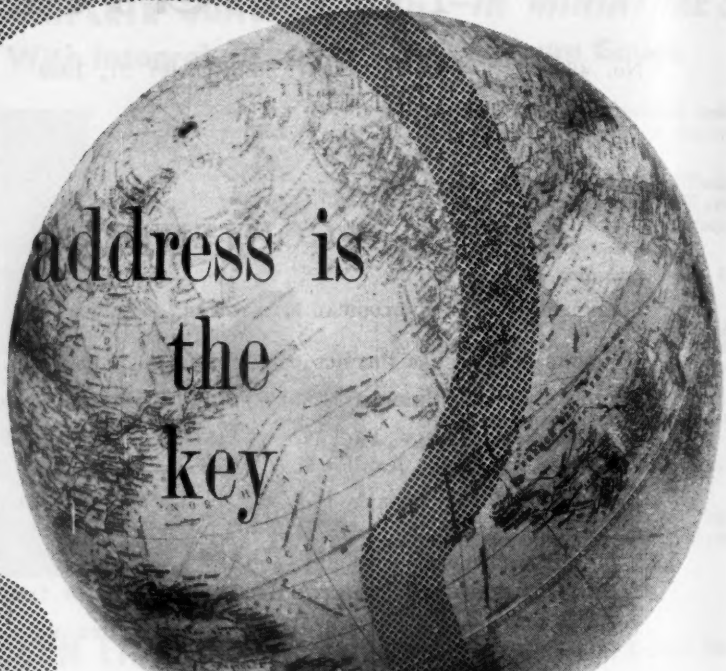

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SCIENTIFIC AND TECHNOLOGICAL MAN-POWER

A COMPARATIVE study of scientific man-power in the public service of Great Britain and selected European countries, including Denmark, France, Germany, the Netherlands, Norway, the U.S.S.R., Sweden and Switzerland, was undertaken by Mr. E. McCrensky* primarily to throw light on the management of scientific man-power in the United States. It provides, however, much more than an appropriate background to the survey of the problem of scientific man-power as it presents itself in the United States made by Mr. D. C. Greenwood†. Its chapters on the higher education of engineers and its survey of the organization for research in various countries bring to light factors that tend to be overlooked and are highly pertinent to the expansion of technological education in progress in Great Britain, particularly at a time when the structure of the national research organization, and especially that administered by the Department of Scientific and Industrial Research, is under criticism.

The early chapters of Mr. McCrensky's book survey the position and work of scientists in Government service, the methods of attracting to, and retaining, scientists in such careers, the payment for professional public services and the representation of scientists; and in the final chapter he summarizes the administrative methods and training practices he has observed and emphasizes particularly the features which could be applied elsewhere. Much of the material he has collected has not hitherto been published, and it is notable how well British practice stands out in comparison with that elsewhere. Indeed, it would seem that in some respects the Scientific Civil Service in Britain is far ahead of other Western countries and the United States, and that most countries have scarcely grasped the importance of the principles laid down in the Barlow report on scientific staff fifteen years ago for the effective use of scientific man-power.

As Sir Harry Melville points out in a foreword, the problems of handling scientists tend to become similar wherever they are studied, and although the book is concerned primarily with the use of scientists in the service of the State, the problems that arise are interlocked with the conditions that exist elsewhere—in industry, in the public corporations and in the universities. Differentials in salary arrangements and policies, in the opportunities and freedom to organize research work, to discuss scientific problems and the professional encouragement which is given, all play their part in attracting men and women from one sphere to another and in holding them there; and conditions of service in general must be considered in relation to the conditions and opportunities available to the scientist both in his own country and abroad. Apart from this, Mr. McCrensky recognizes the importance both of wise and sympathetic management and the bearing of favourable working conditions on effective scientific activity as on other creative work.

This survey of Mr. McCrensky's firmly dispels the idea that the scientist should be merely 'on tap' and not, where he possesses the requisite administrative ability, 'on top'. Mr. McCrensky recognizes, indeed, the difficulty of securing the essential flexibility and of deciding at what point in a scientific career to encourage positively the development of some understanding of the principles of administration, management policies and skill in handling people; but he believes that the British Civil Service is in the vanguard, not only of the countries of Western Europe but also of the United States, in its concrete attempt to meet this need. He points, as example, to the residential conferences run by the Treasury, lasting about eight days, and attended by about twenty senior scientists, engineers, architects and administrators, selected from different fields so as to secure the maximum of cross-fertilization of ideas.

Effective communication is undoubtedly a key factor in the management of scientists and securing effective co-operation, as indeed the experience of operational research during the Second World War indicates; and the encouragement in such ways of clearer and more personal understanding of the distribution of responsibilities in government could also help to stimulate the readiness of scientists to share such responsibilities and fit them for such posts. Moreover, even more important, it could help to balance that inherent difficulty in recruitment for government service, in which, in contrast to industry, the same fixed salary is offered to the marginal as to the brilliant candidate. Here again the British Scientific Civil Service at its higher levels is regarded as more sensitive to the special needs of those engaged in creative scientific research than those of any other country of Western Europe, and reference is made particularly to the composition of the Civil Service Commission and to the Interdepartmental Scientific Panel, and to the consistent and uniform application of the principle that scientists and their work can only be properly and acceptably evaluated by their peers.

Nevertheless, Mr. McCrensky makes some criticisms. The rate of promotion in Britain is slower than in the United States, although comparing favourably with most West European countries. The stratification among the three classes in the Scientific Civil Service is sharply defined, reflecting

* Scientific Manpower in Europe: a Comparative Study of Scientific Manpower in the Public Service of Great Britain and selected European Countries. By Edward McCrensky. Pp. ix+188. (London and New York: Pergamon Press, 1958.) 40s. net.

† Solving the Scientist Shortage. By David C. Greenwood. Pp. viii+68. (Washington, D.C.: Public Affairs Press, 1958.) 2 dollars.

to some extent the national education system. Mobility is also limited by the rigid maximum age limit for entry into the scientific officer class, which normally debars individuals more than thirty-one years of age from competing for permanent posts in the Government service. Finally, some stress is laid on the disparity between the salary scales for the highest positions in the scientific class and those in the administrative class.

These criticisms are relevant in considering the expansion of university and technological education in Britain, for they indicate weaknesses which could well be accentuated as expansion proceeds and even partly frustrate its very purpose. European experience generally confirms the importance of leaving the selection and promotion of scientists so far as possible in their own professional hands within the public service, and affording the broadest possible latitude of self-determination of their administrative responsibilities. Again, the status and prestige of scientific organizations in the public service are enhanced and sustained by the continuous contact of their staff with scientists of the highest standing in other sectors of national life, and Mr. McCrensky instances the value of the National Research Committee in France and its participation in the National Scientific Research Centre. France, as well as Norway and Denmark, uses long-term contracts to provide a higher salary-range in compensation for typical service rights and benefits; but the permanence of tenure conferred by a permanent appointment is a distinguishing characteristic of the systems described in this book. The British Scientific Civil Service certainly demonstrates the practicability of pursuing a life-time career in government service under conditions which do not discourage creative scientific work; but the survey points to the need for strong personal leadership at the highest level if a Government personnel system is to meet the needs of scientists and engineers, as well as for the support of representative leading scientists.

As regards payment for professional public service, Mr. McCrensky's survey suggests that generally Civil services need to establish efficient and reliable internal means for collecting and evaluating current information on prevailing salaries for reasonably comparable positions elsewhere as a basis for a sound policy. Modification of national systems based on a rigid complement of positions within each grade is regarded as offering a major opportunity of improvement, and in this connexion he cites the system followed in the Netherlands by the Central Organization for Applied Research and the 'merit' type of promotions used in the British Scientific Civil Service. The contract type of employment used for engineers in Denmark could also be used more frequently, and provision of a differential of pay allowances and additional leave to the higher levels also merit consideration. Sometimes the necessary flexibility in establishing salaries for scientists and engineers can only be gained by separating government scientific activities from the Civil service, as has been done to some extent in Denmark for engineers, for applied research in the Netherlands and for basic and applied research in the National Scientific Research Centre in France.

The establishment of an independent panel of distinguished citizens to advise the government on its pay policy is also suggested as a constructive measure; but it is not clear what advantage this step would offer over the existing interdepartmental scientific panel in Britain. Part of the problem for the scientist is to translate his views and needs into terms of government administration, and this is unlikely to be done better by those who are not his professional colleagues. This is the key problem in the representation of scientists, and Mr. McCrensky thinks that the attention which has been given to it in Britain in the structure of the Civil Service Commission and the Panel is a distinctive mark of the British system and one that is conspicuously missing from other Civil service systems. He notes, however, that the influence of the Commission is limited to recruitment, and that it has little authority for subsequent leadership. Largely, however, this seems again to be a problem in communication, for in modern governments heads of departments and ministries seem to be precluded by their broad scope of functions and responsibilities from understanding precisely the needs and points of view of the scientist or technologist.

Here, accordingly, the problem is linked up with that of education, for clearly it is necessary to-day that those entering on administrative responsibilities should be equipped by training to have some understanding of at least the approach of the scientist or technologist. That is a condition of the efficient use of trained man-power, and in its absence we shall not make full use of the increasing numbers of scientists and technologists now coming from the universities and colleges of technology. Curiously enough, this point is overlooked by Mr. McCrensky, although in considering the higher education of engineers he notes as probably applicable elsewhere the incorporation of humanistic subjects in the curricula of the technological institutions at Delft and Zurich, and the Norwegian policy of training a proportion of engineers abroad as a progressive measure to broaden their cultural background.

It is such suggestions rather than specific recommendations that mark Mr. McCrensky's survey. He notes features that could be considered for adoption or adaptation, but is aware of the danger of attempting to transplant practice or policy from one country to another without regard to differences in traditions and conditions. Consistently, however, he found a wide gap between the identification and full knowledge of major problems in the efficient management of scientists in the public service, and the initiation of action required to alleviate or eliminate such problems.

Mr. Greenwood, in the second book referred to, attributes the shortage of trained man-power in the United States mainly to about a dozen factors, most of which operate also in Great Britain and other countries. The low birth-rate of the 1930's caused a decline in the enrolment in college in the early 1950's. The failure of many talented youths to

complete their high school or college courses was due to various causes. Relatively long training periods, shortages of qualified teachers, inadequate facilities and equipment for research and training, current heavy demands for technologists and scientists and the failure of the educational system to anticipate the increasing demand for technologists all contributed to the shortage, as did predictions of a surplus of engineers, the periodical appearance of 'scare' articles, low salaries and the demand for, and response to, technical assistance abroad.

Mr. Greenwood's recommendations for solving the shortage follow surveys of the educational outlook in the United States, which have stressed the importance of not allowing the scale, quality, character and flexibility of American education to lag behind its increasing responsibilities, of the Government demands for scientific and technical man-power, and those of private industry and of professional programmes designed to deal with the situation. They fall into seven groups according to whether they are addressed to industry, to the Federal Government, to educational institutions, to chambers of commerce, to State Governments, to professional bodies or to the general community. Most of them fall into the first two groups; but of those addressed to industry only about a fifth are concerned specifically with relieving the man-power shortage, the remainder being directed to raising professional standards or qualifications and increasing the efficiency with which scientific man-power is used.

Under the first heading fall recommendations for encouraging participation in professional activities, including the publication of technical papers and attendance at technical meetings and advanced courses. Under the second, besides more attention to providing appropriate conditions for professional work, relieving trained men and women of work which makes no demands on their professional competence is recommended, as well as providing full auxiliary facilities, and the recognition of competence above average. To relieve the shortage more specifically, Mr. Greenwood suggests full use of older scientific personnel of fifty or sixty, who have several years of useful and productive work ahead of them, and the use wherever practicable of skilled handicapped workers, as well as of qualified women. Trained man-power is also conserved considerably by improved methods of management, including the three-shift system to make maximum use of available equipment. Stress is again laid on the importance of an adequate number of technicians, and there should be no compulsory retiring age for engineers and scientists.

Among the recommendations addressed to the Federal Government, the simplification of the administration of secrecy clearance is strongly advocated, and the more realistic classification of secret material. Stress is laid on the translation of Russian technical literature and the value of greater interchange of allied scientists. But for the rest, the recommendations are directed towards providing a scientist as adviser in each Department of State in which science plays a part and ensuring that the use of scientists in work on defence is properly co-ordinated, overlapping eliminated and that scientists in the Armed Forces are used only on duties which demand their professional knowledge and qualifications. Those addressed to educational institutions contain a number which in Britain would properly be addressed to the Government, and it is interesting to note that while special attention to the brilliant and promising student is recommended, Mr. Greenwood also suggests discontinuance of the present practice of spending time and thought on the maladjusted at the expense of the brilliant child. No less forthright is his advocacy of eliminating courses of no real academic value before we produce a generation of well-adjusted ignoramuses—a warning it would be rash to regard as applying solely to the United States.

Other educational recommendations relate to the salaries of teachers, the maintenance of academic standards and the diversion to technical colleges or similar institutions of as many as possible of the 50 per cent of the engineering students in United States universities who at present fail to complete their courses. The suggestions addressed to professional associations appear to be comparatively minor, and urge closer liaison with the universities and colleges and steps to encourage interest in the schools in science and engineering as careers. Those for the general community note the importance of according scientists and technologists adequate status and recognition.

There is thus little that is new in Mr. Greenwood's recommendations, or that has not already been suggested in Britain in such reports as that of the Willis Jackson Committee or that on "Early Leaving". Surprisingly, comparatively little is said about expanding the output of scientists and technologists: the emphasis is all on eliminating the waste of trained man-power, whether by ensuring it is engaged on tasks that demand professional competence or by providing the conditions under which the scientist and technologist can work most effectively. There is likewise a definite emphasis on the early removal from higher educational institutions of students who seem unlikely to complete their courses, and to make the places available for more talented or satisfactory students as early as possible. The emphasis is all on encouraging ability, and especially outstanding ability, rather than bolstering up mediocrity.

There is, on the whole, a striking parallel between Mr. Greenwood's conclusions and the comments in the latest report of the Advisory Council on Scientific Policy on the scientific and engineering man-power situation in Britain. The key to the removal of the shortage remains the supply of teachers of science and mathematics, and no new suggestions are made for dealing with this situation. Both surveys, in fact, point to the imperative need of action here, and give the removal of the particular shortage of science teachers a priority and an urgency which is lacking in the latest White Paper on secondary education in Britain. Nevertheless, that White Paper does recognize the bearing of an adequate supply of technicians and craftsmen on the efficiency with

which the nation is able to use its scientists and technologists. But both Mr. Greenwood's survey and that of Mr. McCrensky deserve to be studied by the Minister of Education and the Lord President of the Council, for they point unmistakably to the essential factors which will determine the success or failure of efforts in Britain to increase the supply of scientists and technologists to a level commensurate with the nation's needs, and to ensure that the maximum use is made of the men and women thus trained.

CONCEPTS OF NUCLEAR PHYSICS

Nuclear Structure

By Leonard Eisenbud and Prof. Eugene P. Wigner. (Investigations in Physics, Vol. 8.) Pp. viii+128. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1958.) 25s. net.

THERE are surprisingly few up-to-date text-books of theoretical nuclear physics which may be recommended to the final-year honours student or to the postgraduate beginner. Many books have been written containing a wealth of detail both inessential and confusing to the beginner; several which treat particular topics at some length but fail to give any sense of balance; only one or two of the calibre of this one, and these are mostly out of date owing to the speed at which nuclear physics has grown. In the space of a little more than one hundred pages the authors present a clear and balanced account of the whole of low-energy nuclear physics. As one would expect of Prof. E. P. Wigner and Dr. L. Eisenbud, the book is entirely theoretical in its approach, although essentially non-mathematical. That is to say, the authors have dispensed with the usual long-winded accounts, so common in elementary text-books, of the process of acquiring the data on which the interpretation is based. There are some nuclear physicists who will frown at this even to-day: yet even they would not expect to describe the workings of an ammeter during a discourse on the conductivity of metals, or the properties of spectroscopes while expounding the electronic structure of atoms. The techniques of nuclear physics, both experimental and mathematical, can be found elsewhere: here one will find the concepts.

The first three chapters are descriptive, giving the general features of nuclei, their energy systematics and ground-state properties. As an illustration of how up to date the book is, one notes that the values quoted for nuclear radii are those recently obtained by Hofstadter using the scattering of high-energy electrons. The fourth chapter gives a correspondingly descriptive account of the various types of nuclear reactions. At the end of this chapter occurs about the only reference to practical matters, in the delightfully succinct sentence: "Nuclear reactions can be used to produce radioactive elements". The fifth chapter gives a brief account of the properties of the two-body system and of nuclear forces. Here again one finds a modern picture, with Levy's potential, complete with hard core, appearing in the most unembarrassing fashion. The three following chapters are concerned with the various models which have been put forward to try to understand nuclear properties. Only the essential assumptions and most significant results of each model are discussed, and the relations between them. There follow two chapters on the theory of nuclear reactions, the first of which gives a beautiful and almost painless account of the powerful R-matrix theory (or rather of its essential concepts, for it is only the details which are gruesome and these are omitted, in keeping with the rest of the book), the second an account of stripping reactions and Coulomb excitations. Resonance formulæ, reduced widths, radioactivity, complex potentials, giant resonances—they are all included within a very few pages, without fuss, and yet, somehow, with sufficient explanation to make one feel one really understands it all. The final two chapters deal with beta-decay and with electromagnetic transitions. Here, unfortunately, the book is already obsolete: scalar and tensor reign supreme and parity goes inviolate. A most valuable addition is the list of carefully selected references, which are commented upon by the authors so that an inexperienced reader can easily find his way to the vast modern literature.

The critical reader may certainly find some faults. There seem to be one or two misprints, and it is a pity that the word 'Fermi' has been introduced as a synonym for 'barn'. Although the usage is historically correct, the Fermi is now almost fully established as the nuclear unit of length. One may wonder why the LS- and jj-coupling models are presented in such contrasting tones: most people to-day would regard them as extremes of a very narrow band of colours. But these are quibbles. It is an excellent little book, warmly to be recommended to anyone who wishes to obtain an authoritative and balanced view of the concepts of nuclear physics. Even the price is a welcome surprise.

B. H. Flowers

FLUID SYSTEMS IN CHEMICAL ENGINEERING

Chemical Engineering Practice

Edited by Herbert W. Cremer and Trefor Davies. Vol. 5: Fluid Systems I. Pp. vi+695+xxiv. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 95s.; 13.30 dollars.

THERE is probably no aspect of chemical engineering that has received greater attention, and which so clearly indicates the special nature of this technology, than that of distillation. In the petroleum industry the installed capacity for distillation is greater than that for any other operation, and the modern petrochemical industry as well as the conventional organic chemical industry are wide users of distillation equipment. A large section of this volume is taken up with an account of the techniques of, and equipment for, distillation, and for this reason alone this work will receive much attention. The allied operation of liquid – liquid extraction is also covered, so that we have here an exposition of two of the really important chemical engineering operations which have been widely developed by chemical engineers. There are other important sections which will prove of considerable value not only to the professional chemical engineer but also to that wider body of engineers whose work brings them to chemical engineering from time to time. The main topics discussed are transportation of liquids and

gases, the design of high-pressure vessels, the production of vacuum, liquid – liquid stage-wise operation, and distillation.

In the first chapter, Hey gives a summary of the types of pump available for handling liquids, including an adequate account of their construction and maintenance, and a very useful note on methods of controlling flow. One might have expected something on the newer types, such as electromagnetics, and some greater detail on the important class of metering pumps.

The next section, on the transport of gases, by Messrs. Barrett, Jackson and Brown from Imperial Chemical Industries, Ltd., contains a most readable discussion on blowers, fans and compressors, and is improved by having two examples worked out. Williamson, also from Imperial Chemical Industries, Ltd., provides a really practical guide to the design of pipe systems, in which he has condensed much practical experience in a chapter on a topic not previously discussed in the literature.

The design of high-pressure equipment is covered by Prof. D. M. Newitt and Mr. K. E. Bett, of the Imperial College of Science and Technology, London. The difficulties of creep, of high temperature, of gaseous diffusion, and of embrittlement are well brought out and the various methods for design and construction are described. They give a large number of references which are helpful; but work in this field calls for specialization for the few, and this chapter serves rather to underline the problems as seen by chemical engineers than to provide detailed design solutions which are more properly the province of mechanical engineering. One would like to have seen something on the heavy cost per unit volume of reactors for very high pressures.

Section 5, by Barrett and Power, from the Edwards High Vacuum Company, provides a good account of the selection of equipment for this duty. While there is some repetition of earlier work on fluid friction, the real problems of flow at very low pressures are well explained with one or two illustrations.

Almost the whole of the second part of the book is devoted to the operations of liquid – liquid extraction and of distillation. Prof. F. H. Garner and his colleagues from Birmingham first describe the nature of the phase equilibrium in liquid – liquid systems both for ternary and multicomponent systems and then outline the calculations required to determine the number of stage-wise units required. The section on selectivity of the solvent is perhaps the most interesting, and the illustrations of the use of the triangular and rectangular co-ordinate diagrams will help many readers. The examples given here are both well chosen and well presented.

In a somewhat parallel chapter, Prof. S. R. M. Ellis describes the calculations of the stages required for a distillation operation. He gives all the normal methods and illustrates them with good examples. He has provided a useful analysis of the batch still, a subject too frequently neglected.

The section on equipment for both operations is by Dr. Freshwater, and, although he describes the problems of entrainment, capacity and pressure-drop, one is left a little wondering if it all fits together. One really good example from practice would have brought out the order of magnitude of the various terms and left a clearer idea of the operating conditions. The use of computers for the calculation of changes in composition in stills with multicomponent systems is not indicated, and little is said as to the range of temperature and pressure for which the design techniques are satisfactory. The problem of handling widely different ratios of liquids and gases is not emphasized.

This volume catches the spirit of chemical engineering; there is no doubt one is dealing with real chemical plant. This is a good text which will be used by many.

J. M. Coulson

INTELLIGENCE, FAMILY BACKGROUND AND EDUCATIONAL PROGRESS IN SCOTLAND

Eleven-Year-Olds Grow Up

By John S. Macpherson. (Publications of the Scottish Council for Research in Education, No. 42.) Pp. xxiii+184. (London: University of London Press, 1958.) 15*s*. net.

THE Scottish Council for Research in Education here presents the first report on the information it has been collecting since 1947 concerning the educational and vocational progress of some 2,000 children born in Scotland in 1936. This group of children is a representative sample of all those born in that year; it is, as the report suggests, a "Scotland *in miniature*", "*ranging over the whole scale of* intelligence, born in every month of the year, from different social classes, from Lowlands, Highlands and Islands, from village, city and town, from large families and small". The report describes what has *happened to this Scottish sample between 1947*, when the last mental survey of the whole age-group was undertaken, and 1954, by which time practically all had left school and chosen or embarked on their first occupation. Many matters of interest and importance are dealt with; the effect of parental ambitions and sex differences on occupational choice, relationships between the occupations of sons and fathers, change of occupations, the attitudes of young workers to further part-time education, the leisure interests of young people and the attitudes of boys to National Service.

The report hinges, however, on the examination of the relation between measured intelligence at the age of eleven, and the subsequent educational and vocational progress of the pupils in the sample. It is, in fact, a description in some detail of the process of educational and occupational selection in Scotland, as reflected in the experiences of the age-group of children who entered secondary schools two years after the Second World War. The two questions of interest are the value of measured intelligence at the age of eleven as a predicter of future academic and vocational achievement, and the possible biasing influence of extraneous social factors on the process of educational and occupational selection whereby talent should find its own level.

So far as the predictive value of measured intelligence is concerned, the report makes it clear that this is limited to estimating for a group of pupils the proportion likely to be successful in following a particular school course or class of occupation, but that it would be impossible to predict on this basis alone the individual pupils who would go to make up the successful group. However, one further piece of information about each child involved makes it possible to predict relative chances at least one degree more accurately, and that is the father's occupation.

Social factors are strongly at work in the process of educational selection. The report under review, like that of the Central Advisory Council for Education in England ("Early Leaving", H.M. Stationery Office; 1954), although in a technically more refined manner, shows a relationship in the selective secondary school between the father's occupational class and a child's chances of completing the course and proceeding to advanced work which is practically independent of intelligence quotient (*IQ*). Thus, in the Scottish sample, for able boys with an *IQ* greater than 120 coming from working-class families (namely, those whose fathers are manual workers) the chances of completing the course are about 2 in 5; but for similarly able boys from other (that is to say, non-manual) families, the chances are about 2 in 3. For those with an *IQ* less than 120 there is the same difference in chances according to social background; for working-class boys at this level of ability they are about 1 in 5, but for others 1 in 2. However, the Scottish report explores the implications of this striking finding much less thoroughly and imaginatively than the English report. Related findings, such as that early leavers tend to be deficient in personal qualities such as industry, or had very difficult home circumstances, or did not find the course interesting or useful for the career they had in mind, or were known not to be succeeding in the course for other known or unknown reasons, are accepted at their face-value as psychological irreducibles. The English report, on the other hand, examines the possibility that those factors are systematically related to sociological variables such as father's occupation, size and sex of the school, or the social and economic character of the neighbourhood in which it is situated. Clearly these are the lines, sociological rather than psychological, on which further work on the problems of educational selection and performance must proceed. JEAN FLOUD

CRITIQUE OF WITTGENSTEIN'S PHILOSOPHY

The Later Philosophy of Wittgenstein

A Short Introduction, with an Epilogue on John Wisdom. By Dr. David Pole. Pp. vi+132. (London: The Athlone Press, University of London, 1958. Distributed by Constable and Co., Ltd.) 15*s*. net.

IN this book, small in size but weighty in learning, Dr. D. Pole sets out to be an interpreter and, in part, critic of Wittgenstein's later thought as expressed in his posthumous writings. Appropriately enough, a chapter is included on the work of Prof. Wisdom, whose method is characteristically British, though he has done much to graft it on (and this is in itself no mean achievement) to the Germanic, and even Hegelian strain running through Wittgenstein.

These essays begin with a discussion of the linguistic approach to philosophy, followed by some detailed observations upon logic and normative language, together with the place of inner experience. The main theme is rounded off by a consideration of the difficulties in Wittgenstein's philosophy. In all this, one cannot be blind to the immense change which came over Wittgenstein since he first startled the learned world with the "Tractatus" in 1922.

A favourite illustration is that of a machine running idle, or of a wheel spinning freely without engaging with the rest of the machinery. Such a mental situation derives from forgetting that language is something which we inherit, whereas a calculus is a deliberate construct. Noteworthy, too, is the view that for Wittgenstein a mathematician is more an inventor than a discoverer.

Yet Wittgenstein, himself no professional mathematician, helped that discipline substantially in several ways, not least by the realization that "in working with shapes, we create our concepts".

Perhaps it is hereabouts that Wittgenstein makes an incidental contribution of importance to psychology in throwing up, as it were, the nature of boundaries as perceived in geometric figures. This is common ground for *Gestalt-theorie*, behaviourism, and even for parts of isomorphism. Some of these may be out of fashion but they are part of man's heritage, and Dr. Pole has done well to include hints of them in his valuable study. F. I. G. RAWLINS

THE CLERK IN INDUSTRY

The Blackcoated Worker

A Study in Class Consciousness. By David Lockwood. (Studies in Society.) Pp. 224. (London: George Allen and Unwin, Ltd., 1958.) 21*s*. net.

THE position of the clerk in industry and commerce has changed considerably during the past forty years. Before the First World War the clerk commanded authority and respect *vis-a-vis* the manual worker. Because of his closeness to the employer he was paid more, was treated as a person of considerable status both because of his knowledge of the company's secrets and because of his literacy, and often succeeded to posts of management responsibility because of his experience in administration. Now, as David Lockwood shows in a scholarly, well-planned and carefully written investigation, the clerk's position is generally very different.

In the days of the counting-house, clerks were nearly all male and were recruited from middle-class families, frequently from the homes of clerks themselves. To-day, much of the work in a mechanized office is done by females, many of whom—as well as their male counterparts—are recruited from the lower social strata. Up to 1914 the ordinary adult clerk earned roughly the same as a skilled manual worker. In 1958 even the aristocracy of blackcoated labour—the banking and insurance clerks—no longer enjoy an economic status clearly distinct from the wage-earning classes; the mass of clerks are roughly on the same income-level as the average manual worker. The clerk's position is also changing relative to that of the manual worker with regard both to job security and 'fringe' benefits.

These are some of the generalizations which emerge from factual information so painstakingly gathered and sifted by the author. They reinforce the experiences of all who are concerned with the place of the clerk in industry and commerce and should illuminate the implication of modern trends. Reduced pay differentials, greater job insecurity and the difficulty of finding other jobs when declared redundant, as well as lessened chances of promotion with the introduction of management trainees, are some of the factors combining to make the clerk's position more unstable. As a consequence, many firms are already finding it difficult to recruit sufficient clerks of the right quality. Lockwood's book should be read by all employers who are faced with this problem and are prepared to tackle it before it becomes too unwieldy.

A NEW SOLUTION TO THE ATLANTIC EEL PROBLEM

By Dr. DENYS W. TUCKER
British Museum (Natural History)

TWO nominal species of Atlantic eel (*Anguilla*) are currently recognized, mainly distinguished by their myomere/vertebra counts. *A. rostrata* (Le Sueur) of North America has 103–111 vertebræ (mode 107); *A. anguilla* L. of Europe and North Africa has 110–119 (mode 115). These two eels are more closely allied in every respect than either is to any other[1]; the remaining discriminating characters comprise small differences in mean numbers of branchiostegals (11·03 : 10·78), pectoral rays (16·73 : 17·37), etc., and minor differences of body-form of no greater importance than those formerly held to justify the recognition of a dozen European 'species'[2]. Both include 'long-nosed' and 'broad-nosed' varieties; both have a sexual disparity of size. Their larvæ "are outwardly so alike as to be hardly distinguishable"[3].

Two thousand years of speculation on the life-history of the European eel[2] culminated in the classic solution of Schmidt[3,4], a well-publicized saga which scarcely requires detailed repetition. Schmidt, sorting the *A. rostrata* and *A. anguilla* leptocephalus larvæ on their myomere counts, laboriously plotted the limits of distribution of larvæ of various lengths (Fig. 1) and so eventually traced their apparent origins to two supposedly distinct, though partially overlapping, areas in the region of the Sargasso Sea which were presumed to embrace the actual spawning-areas. The last was an assumption based on circumstantial evidence; eggs were never found, and, for those who disallow the careful claim of Fish[5], denied by Schmidt[6] and by Tåning[7], never have been. Furthermore, the *A. rostrata* prelarvæ have yet to be found; *Anguilla* adults have yet to be taken in the open ocean (one from the stomach of a cachalot off the Azores[8] is obviously suspect of local provenance); naturally ripe eels in full breeding-dress (as demonstrated by hormone-injection experiments[9]) have yet to be observed. However, Schmidt did demonstrate the fact of an oceanic spawning and show conclusively that the American eels complete their pelagic stages in one year, whereas the European ones require three years before they enter the inshore waters of their respective continents.

Schmidt's now generally accepted solution demands, not only a long journey on the part of the nearest

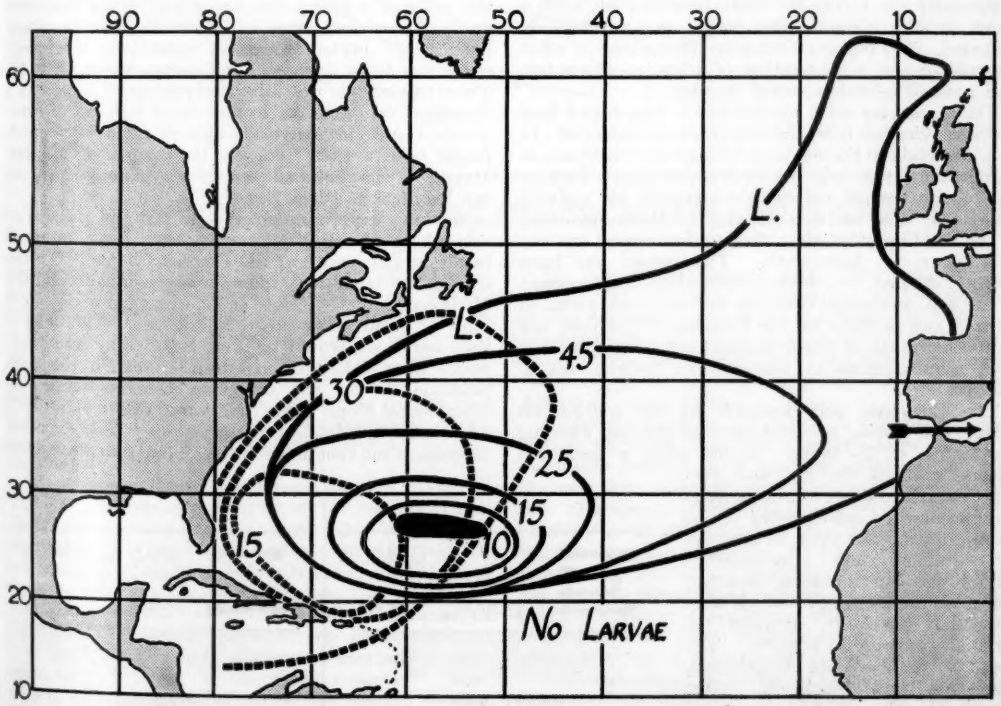

Fig. 1. Distribution of Atlantic *Anguilla* larvæ. ——, *A. anguilla*; – – –, *A. rostrata*. The curves show the limits of occurrence of larvæ of the indicated mm. lengths. The black area shows the distribution of newly hatched (5–7 mm.) *A. anguilla* prelarvæ. Curves *L* mark the limits for unmetamorphosed larvæ. (After Schmidt, refs. 3 and 4)

American eels returning to their spawning area, but a much longer one, of the order of at least 3,500 miles on a great circle course, by the European eels. The present article rejects the latter assumption and proposes a new and drastically different interpretation of the observed phenomena, namely :

(1) That the European eels need not and do not succeed in returning to the ancestral spawning-area, but perish in their own continental waters.

(2) That the American and European eels are not distinct species, but merely eco-phenotypes of *Anguilla anguilla*, their apparent distinguishing characters being environmentally determined (in the manner of numerous precedents) by demonstrable differences in temperature conditions encountered during the ascent from different parts of the American eels' spawning area to the surface, and their distribution by demonstrable coincident differences in the subsequent transport of the surface water-masses.

(3) That the populations of the so-called 'European' eels, *A. anguilla*, are therefore entirely maintained by reinforcements of larvæ of American '*A. rostrata*' parentage.

The evidence and arguments are presented under three broadly corresponding headings.

(I) Evidence against the Return of the European Eel to the Spawning Area

Differences between the morphological and physiological states of the European and American eels on their descent to the sea are remarkable in a context quite apart from taxonomy. The European eel is already well advanced towards being a reproductive oceanic fish, and this despite the long journey which supposedly lies before it. The American eel, with a much smaller distance/time to go, is yet relatively retarded. The two conditions are the reverse of what any reasonable consideration of adaptive characters and natural selection would predict.

The American eel[10], on average a larger and four times heavier fish than the European (females, 56 : 14 oz.), descends to the sea as a 'bronze' or 'black' eel, in a migration livery which is little more than a darkening of the normal colour accompanied by metallic reflexions. Fat has accumulated to about one-third of the total body-weight ; feeding has ceased and the gut begun to degenerate. The gonad has been scarcely studied, but there is certainly no enlargement of the eye, no change from the normal short, rounded form of the pectoral fin, no blocking of the vent nor any assumption of silver coloration[10]. Its condition thus approximates to that of the 'yellow' eel of Europe.

The European eel[2] descends as the well-known 'silver' eel, having a broad band of guanine running the length of its belly. Along with a profound degeneration of the gut and perceptible enlargement of the gonads, there is marked enlargement of the sense-organs ; the eyes, in particular, double their diameter[10,11], though without increasing the number of retinal elements[12] which were previously intensely crowded behind a contractile pupil[13]. The pectoral fin becomes lengthened, lanceolate and black[10,11]. One apparently normal (that is, non-pathological) fish from the North Sea showed complete occlusion of the vent[14]. In very few examples (*post*) has any more advanced gonadial condition been observed in Nature. We have, therefore, in the typical case, a fish degenerate and unable to feed, having a fat reserve which must provide for the maturation and vast enlargement of the gonads as well as for the propulsion of the enfeebled body on a presumed 3,500-mile journey. Instances of longevity in eels (fed or starved) in captivity[2,10,15] are irrelevant to this problem, since their normal physiological modification had, in every case, ceased or regressed after capture.

The European eel shows positive reactions to higher temperature and salinity ; negative ones to solid bodies and to light[2]. Agreed that all *A. anguilla* are derived by passive dispersal from one breeding area, there can be only one common inherited pattern of behaviour, yet this has hitherto been assumed adequate to direct the return journeys of eels leaving points all over Europe and North Africa and successfully traversing a great variety of conditions to a common oceanic terminal. Any lingering resistance to the new hypothesis may be dispelled by a study of Sverdrup *et al.*[16] considering, for example, the complexly involuted current/temperature/salinity conditions in the inner Mediterranean, the flow of Mediterranean water through the Atlantic, the north-going Norwegian Coastal Current which leaves the Baltic and heads for the Arctic, and the complicated counter-clockwise circulation of the North Sea. How could eels regularly negotiate such systems and end up in the western tropical Atlantic ? Furthermore, while theories demanding either passive transport by currents alone or active response to gradients alone are inadequate, since many of the currents are of the order of a mile a day and many of the gradients gradual over vast areas of ocean, theories involving both must, under European conditions, obviously contain a large degree of self-contradiction (Fig. 2). There can be only one inherited pattern of behaviour ; therefore, moreover, a hypothetical pattern of complicated and successive changes of behaviour which might take a Baltic eel via the Azores or via Jan Mayen to the Sargasso would serve no purpose to one leaving the Black Sea.

Marking experiments have proved the passage of eels along the Baltic[17] ; eels have been captured rarely at the mouth of the English Channel[18,19] ; the exodus has been observed at many points around the Mediterranean[20,21]. But these cases provide proof only of local short-range migrations. The eels, if they survived, would be abundant. Why have they never been taken by research vessels in the open Atlantic or by the intensive fisheries along the Continental Slope ? Are agility and this or that depth of swimming adequate explanations ? The expected passage of the vast Mediterranean populations through

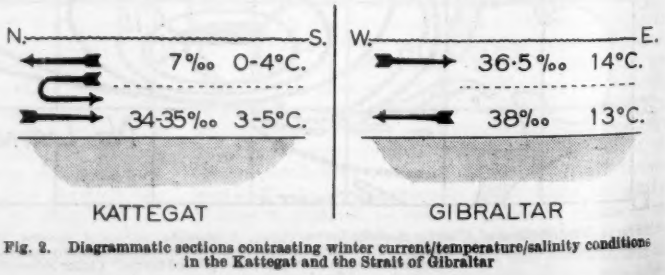

Fig. 2. Diagrammatic sections contrasting winter current/temperature/salinity conditions in the Kattegat and the Strait of Gibraltar

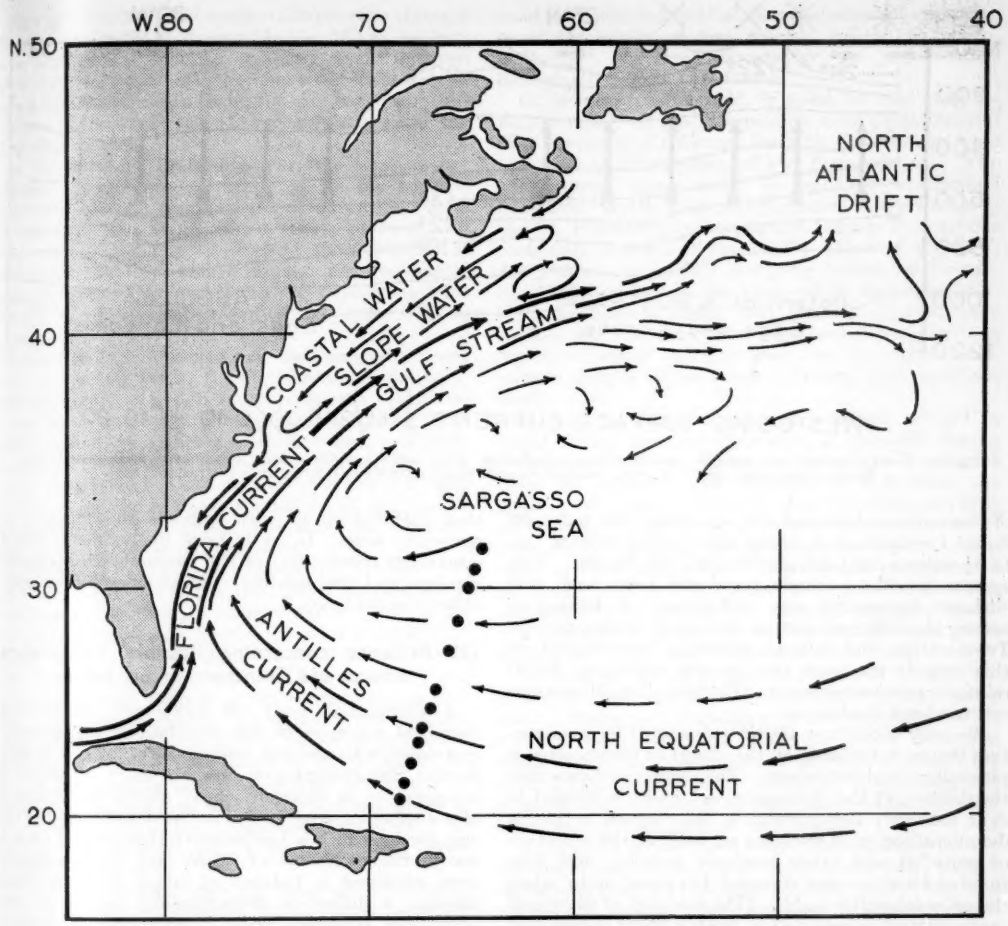

Fig. 3. Atlantic surface currents affecting the distribution of *Anguilla* larvæ. The map also indicates the positions (● ●) of the *Atlantis* stations involved in Fig. 4. (Adapted, after Sverdrup *et al.*, ref. 16, and Iselin, ref. 34)

the sharp focus provided by the Strait of Gibraltar has never been witnessed, despite much study; indeed, Ekman[22] has anticipated me in denying that it occurs, which is already tantamount to saying that the Mediterranean stocks at least are maintained by breeding populations from elsewhere. Quite apart from the difficulties of navigation, it may well be that the distances from the great Mediterranean river-mouths to Gibraltar are already beyond the eels' capabilities.

Supporting evidence comes from another direction. There is a substantial uniformity of condition and unanimity of action in the departure of the eels from the rivers[2]. Yet from time to time isolated individuals are found in adjacent seas in advanced conditions of ripeness; in the Baltic[23], English Channel[19] and Mediterranean[20]. These isolated individuals may be the last survivors of stocks which have migrated from much farther east. Heavy eel-mortalities have been observed even in the Mediterranean[20]; elsewhere, "In consequence of excessively stormy weather this month (Feb. 1655) many thousands of dead eels were cast out upon the banks of the North Loch at Edinburgh, to the admiration of many"[24].

In the Mediterranean, again, are several deeps which offer conditions apparently identical to those of the Sargasso, yet eels do not spawn in them nor anywhere in that Sea[25]. In the open Atlantic the Cape Verde Basin, Monaco Deep and West Indian Basin, all on the obvious migration route, are likewise devoid of young larvæ.

Explanations of the hypothetical long-range migration in the open ocean have ranged from notions of voluntary point-to-point navigations to the idea that the eels first passively ride the Canary Current and are afterwards carried in the North Equatorial Current[26]. A proper scepticism towards all these suggestions has hitherto been inhibited by the inescapable fact of the Sargasso larvæ. Speculation has gone as far as "Les Amours des Anguilles"; the parting words of a legendary watcher by the Rhine may now seem more appropriate[27]: "Ihrem Ende eilen sie zu, die so stark im Bestehen sich wähnen".

The east-coast American migration, by contrast, presents little difficulty. Along that coast the coastal water and immediately adjacent slope water are moving in a south-westerly direction (Fig. 3). Recent *Discovery II* work[28] has confirmed the hypothesis

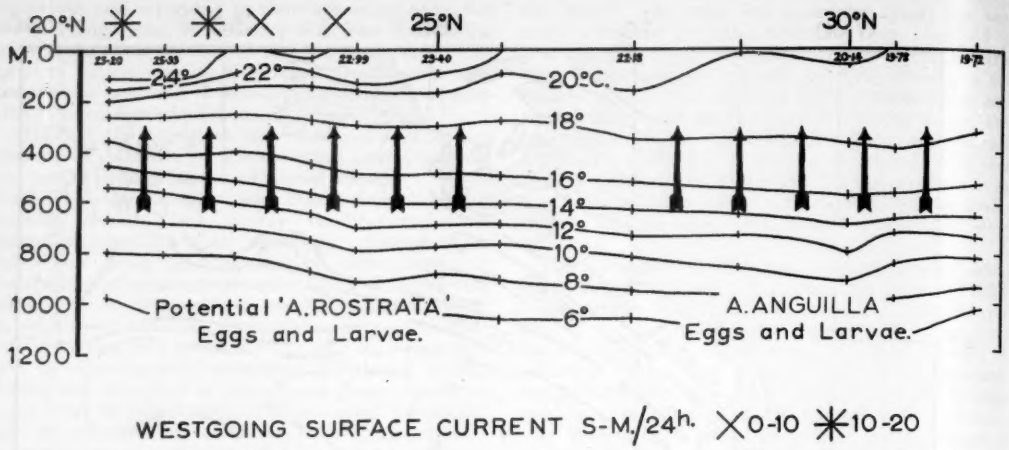

Fig. 4. Section across the *Anguilla* spawning area. Isotherms after Iselin (ref. 34) based on *Atlantis* stations 1208–1219, Haiti to Bermuda, April 7–13, 1932. Surface-current velocities for March inserted after Dietrich (ref. 36)

of Stommel and proved the existence, 150 miles off South Carolina, of a strong south-going current (up to 8½ miles a day) deep under the Gulf Stream. This system provides a simple, rapid and direct path, and without demanding any differences of behaviour among the different eastern groups of American eels. Temperature and salinity gradients encountered on this route[16] are such that active migration would reinforce passive transport. The fate of the Mississippi eels need not concern us.

We may here meet Bertin's demand[2] for a migration theory containing all the observed phenomena of physiology and behaviour. The evidence shows that the debility of the (European) eel which is obliged to drift passively downstream in the current is due to demineralization of the starving body at the inception of gonadial and other hormone activity, and that re-mineralization and resumed liveliness occur when the eel reaches the sea[2,29]. (The survival of silver eels captured and imprisoned in fresh water[15] shows that with gonad-regression continued life is still possible, that is, through re-mineralization accomplished at the expense of the gonad, so that in the early stages the process is reversible.) Thus far no voluntary activity is called for.

With continuing gonadial activity, further demineralization occurs which can only be remedied under conditions of higher ambient salinity. The eel experiences a malaise alleviated by migration towards higher salinity and aggravated by passage into lower-salinity waters; here is the mechanism of the observed halotaxis. Failure to migrate leads, by this stage, to increasing mineral unbalance and to death. The better-adapted American eels migrate until they are trapped in the warmest, deepest part of the North Atlantic Central Water under the Sargasso, in a salinity of 35‰–36‰, where the climactic stages of gonadial maturation, de-mineralization and spawning occur. Death after spawning may be assumed; European males experimentally ripened and spawned died within 12–24 hr. of emission[3], while *Conger conger* is known to become more debilitated after spawning[30,31] than any *Anguilla* yet observed.

The reproductive metabolism is clearly geared to the need to produce gametes which will be isotonic or hypertonic to the water in which they are spawned; that metabolism in turn imposes the selection of spawning area. If, as is very likely, many forced spawnings occur short of the Sargasso, unfavourable osmotic and temperature conditions would speedily efface the evidence.

(2) Evidence concerning Possible Temperature Effects and Transport of Eel Larvæ

A substantial body of evidence[32] shows that vertebral numbers in fish populations are inversely correlated with ambient temperatures. Experimental studies, for example, on *Salmo trutta*[33], of effects of temperature in ontogeny, have shown that there is also a supersensitive period in the development of the egg during which a temperature change may have a shock-effect; means of 56·86 and 60·06 vertebræ were obtained in batches of young from the same parents, a difference proportionally similar to that pertaining between whole populations of Atlantic *Anguilla*. Other meristic characters, such as numbers of rays in median and paired fins, are likewise affected[33], not necessarily at the same time or in the same direction.

If we may assume that *Anguilla* shares the common susceptibility to such factors, hydrological data are available to show how phenotypic differentiation may occur.

Consider the rectangle between 20–30° N., 50–70° W. The surface-current system in this region (Fig. 3) comprises the west-flowing North Equatorial Current with its north-westerly continuation, the Antilles Current. Conditions are substantially similar throughout the moving water-mass just defined[34]; any section normal to the direction of flow provides a fair picture of the whole, wherefore the section Haiti–Bermuda given by *Atlantis* Stations 1208–1219[34] may be taken as a basis for discussion of conditions over the eel spawning area (Fig. 4).

Assume a linear spawning area extending from 20–30° N. and at a depth (400–700 m.) below the influence of surface currents. Eel eggs, rising through the lower layers, will encounter a substantially identical temperature gradient until they strike the 18° C. isotherm at about 300 m. From then on several conditions become differentiated simultaneously, roughly in relation to latitude.

Eggs and larvæ at the southern limit pass through the gradient 18–25° C. during the last 250 m. ascent; in particular, they encounter an abrupt 4° rise between 200 and 100 m. which may well have the effect of ending segmentation and so fixing the number of somites/vertebræ in the range 103–111 recognized as typifying '*Anguilla rostrata*'.

At the northern limit, however, the temperature gradient remains gradual right up to the surface, where a maximum temperature of barely 20° C. is encountered. No temperature effect, certainly no shock effect, is likely, wherefore the addition of somites presumably continues to the genetically determined limit and results in the population with 110–119 somites/vertebræ which we recognize as *A. anguilla*.

Further biological effects may be assumed. First, in the '*A. rostrata*' larvæ, the higher ambient temperatures must result in a higher metabolic rate, supported by the higher zooplankton concentrations along their route[35], hence the higher growth-rate and, probably, the shorter larval life; duration of life and growth-rate in the adult have not been studied but may also be affected by the extreme conditions of this earlier phase. For the *A. anguilla* population the converse assumption and observations hold.

Secondly, as in any such system, the Antilles Current runs deeper[16] as well as faster[36] at its periphery. This means that the '*A. rostrata*' larvæ begin to be transported westwards while still at a considerable depth; for the *A. anguilla* larvæ such lateral movement does not commence until they approach the surface, and even then is much slower than in the other case. Consequently our original north–south linear spawning area produces, some weeks after spawning, a surface population of larvæ which lie along a line more or less skewed from north-east to south-west. A spawning-area pattern of any shape or size, lying between the prescribed limits, will be similarly transferred when the resulting larvæ approach the surface.

It will be observed that the zone of *A. anguilla* prelarvæ mapped by Schmidt (Fig. 1) tallies with the hypothesis raised in relation to Fig. 4, and there can be no reason for doubting, from the abundance of stations worked and from our knowledge of the hydrological conditions, that this is the spawning area for this section of the *Anguilla* population. The concentric contours of the early stages are likewise compatible with slow migration at random over an area of weak surface currents.

Schmidt's postulate of a distinct '*A. rostrata*' spawning area to the south-west appears invalid. We are given the limit for larvæ of 15 mm., which, at a moderate estimate, must be a month old; resting in a current system travelling at 10–20 miles a day they must be at least 300–600 miles from their point of hatching and up to twice as far from the spawning area. Considered in relation to the Antilles Current, it is evident that the distribution is not compatible with a source lying within the 15-mm. contour. The 15-mm. contour must enclose the surface, the oblique section, of a solid cone of larvæ of diminishing age the truncated vertex (the spawning area) of which lies deeply embedded very much farther back in the current, practically due south of the *A. anguilla* area and contiguous with it. Geographically there is probably only one spawning area altogether, of which the mass of resulting larvæ becomes obliquely and sharply divided and differentiated by the sheer of the sharply defined current. This analysis removes the need for belief in a critical discrimination of spawning areas by adults of two species, related to micro-isotherms[2], bottom topography or some other biologically improbable factor.

In fairness to Schmidt, it must be said that he lacked much of the information now available and that his terms of reference from his Government were to locate the birthplace of the European eel. The '*A. rostrata*' larvæ were, to him, an unexpected nuisance. In the area now suggested as the source of the '*A. rostrata*' phenotypes the Danish Expeditions took only a score of stations[37]; those of the R.V. *Margrethe* were worked in during November–December 1913, too late in the year, while the remainder, at miscellaneous dates and shallow depths, were worked by amateurs from commercial vessels, in a region of rapid currents and, on my hypothesis, minute deep-lying prelarvæ. Closing nets were not used.

It may be objected that '*A. rostrata*' is said to breed during January–February, *A. anguilla* during February–March[3,7]. Against this simple statement must be balanced the fortunes of collecting, the lengths of overall journeys from various starting-points, disparities in sexual maturation, velocities of currents at various possible migration-depths, durations of spawning periods and annual variations in all these; effects of temperature on rates of hatching and early development and rates of ascent of larvæ over different parts of the spawning area. The criticism is more easily answered than made.

'*A. rostrata*' larvæ reach their limit of 60–65 mm. in about nine months and metamorphose into 'glass eels'[2]. Many, still travelling on the periphery of the Gulf Stream system, lie along the North American coast which they approach as pigmented elvers the next spring, a year after hatching. Some laggards colonize brackish ponds in Bermuda[38]; vast numbers of *A. anguilla* all by-pass that island.

A. anguilla larvæ travel mainly on the inside of the current system (some being trapped for a year or more in the Sargasso[3]) so that large numbers travel east and north-east across the Atlantic. Metamorphosis occurs off the edge of the Continental Shelf, except in larvæ which penetrate the Mediterranean to beyond the heel of Italy. Lower temperatures and metabolic rates prolong the pelagic phases to three years and extend the limit of growth to 75 mm.[3].

Environmental conditions affecting metamorphosis have been little studied. The limits of successful larvæ of both groups coincide with the spring surface isotherm for 8° C., which marks the margin of the Gulf Stream system and coincides with the edges of the Continental Shelves, but there are many complicating factors to be considered: turbidity of inshore waters, lateral mixing with lowering of temperature and increased oxygenation, upwelling of cold water at the edges of the slopes (and off Bermuda ?) and possible changes in salinity relations which would affect the hydration observed at metamorphosis. The situation is too complex for theoretical consideration.

It is, however, certain that thyroid secretion is important at metamorphosis; Murr and Sklower[39] have shown that in the late leptocephalus the thyroid increases to ten times its previous size and regresses again in the glass eel. This mechanism must ultimately be under genetic control (modified by ambient temperatures through metabolic rates); '*A. rostrata*' in mid-Atlantic and *A. anguilla* in the tropical Atlantic normally perish without making landfall and

metamorphosis is delayed only for part of the Mediterranean transit. In both, therefore, whether forms or species, the hormone regulatory system must act ultimately regardless of unfavourable environmental conditions; we shall need this point again later.

The proposition of Schmidt[3] (p. 204, lines 20–40: "How do the masses of larvæ in the Western Atlantic sort themselves out . . . ?") has led to misunderstanding, especially among lay authors. The situation is, that of the mixed aggregations of larvæ, those which make landfall too soon, too late, or not at all are doomed to perish; the former because their hormone mechanism cannot be triggered early enough by environmental conditions, the latter because the same mechanism decrees that metamorphosis can no longer be delayed. The process is not a sorting, but rather an elimination, of the mis-directed and consequently ill-adapted.

(3) Implications of the New Hypothesis

As a syllogism, the new hypothesis may at least claim parity with Schmidt's, since both theories provide an explanation for the origin of the European eel larvæ and both make a single unsubstantiated assumption. As a biological proposition, however, the probability of the assumed effect of temperature, with its numerous precedents, may be considered more reasonable than that of a 3,500-mile directive migration for which there is no parallel among fishes.

The differentiation of *A. anguilla*/'*A. rostrata*' phenotypes is shown to be credible without genetic intervention; the need for a return migration by European eels to the Sargasso has been removed, so that this problem may be considered divorced from any assumption that it must occur; and we are left with the implication, seemingly more likely and no less remarkable, that Europe and North Africa are regularly colonized by eels of American ancestry doomed to perish in a fruitless suicide-migration.

It remains to provide an explanation of the physiology of the European eel. We know that males attain the age of 7–12 years, females 9–19 years in fresh water[2]; we also know authenticated cases of eels in captivity attaining an age up to 88 years under conditions in which sexual maturation was suppressed[10,15]. The disparity is remarkable; many cases are known of the antagonism between growth and reproductive metabolism, and of animals which breed once and then die; but there is surely no parallel to this. The desperate rapacity of the eel is well known; moreover, Bertin[2] shows that growth-rates vary enormously in different European rivers, evidently in relation to size of water and available supply of food. From this evidence and from considerations of early larval life an explanation can be drawn.

Migration and sexual maturation in *Anguilla* are controlled by a hormone system—hypophysial[40], thyroidean[41] and gonadial[42]—which is certainly genetically determined and, by my hypothesis, preconditioned by early environment. Growth in length appears to be genetically limited[10,43], but growth in bulk is subject to external environmental conditions of temperature, living-space and supply of food. Under American conditions (fishery statistics[10] almost permit us to say St. Lawrence and Great Lakes conditions) of higher ambient temperatures in the larval stages, larger rivers and better supplies of food throughout life, the predetermined sexual maturation and environmentally determined growth-metabolism are synchronized in a viable life-cycle. Under less-favourable European conditions, the predetermined hormone system functions prematurely, and the mechanism of sexual maturation is invoked before the body can sustain its consequences. We have already seen this hormone system in action under unfavourable conditions in mid-Atlantic larvæ; if it can act catastrophically at the first metamorphosis it can surely do so at the second? The disparities in mean weights of American and European eels point to this view, as do the longer stays of the females, the gonads of which have, under optimum conditions, to accumulate greater resources of food. The disparities between American and European eels on their departure likewise fit the picture; the European eel delays to the last possible moment and the migration livery appears before the still premature (and unnecessarily premature) migration is invoked. Environment may advance migration activity a little (in the American eel) or retard it (in the European), but outside the permitted range of variation, in the adult as in the larva, there can be no modification of an inexorable predetermined system.

Since selection pressure upon the Atlantic *Anguilla* acts only in relation to American conditions there is no means by which the deadlock of the 'European' eels can be broken; they represent, in perpetuity, the waste of a major part of the American eels' breeding-potential, compensated for by the adequate numbers of the latter and the ten million or so eggs[10] which a female can produce.

Conditions for the proof of either hypothesis are easily formulated, if difficult to execute. Schmidt's requires the capture of ripe 'European' eels in the spawning area. Mine, the easier, would require experimental production of '*A. rostrata*'-type larvæ from artificially fertilized 'European' eel eggs; alternatively, from eggs collected at the northern limits of the original *A. anguilla* spawning area. The last experiment may have been performed already, quite inadvertently, unknowingly and successfully, by Fish[5].

On July 16, 1925, the *Arcturus* collected four eggs from 500 fathoms at 32° 02′ N., 65° 00′ W., which were reared in the laboratory by Fish and carefully and responsibly reported as *A. rostrata*; criticism of this identification[6,7] does not seem to be conclusively destructive. One larva was reared and had "between 105 and 110 muscle segments" when it died at 10 mm. An embryo had "at least 105 and not more than 109 segments", about 64 of them pre-anal and 41 post-anal. The temperatures of the water during incubation were recorded: 27·7° C. when cleavage began to 23·9° C. at hatching, a range of the order of 10° C. higher than that which would have been encountered in Nature. Thus, from north of the original *A. anguilla* ground were reared, under conditions in which a temperature effect must appear inevitable, larvæ which were arguably of '*A. rostrata*' type. That the eggs were so far north and late in the year and lacking a concentrated oil-globule, facts cited against the *Anguilla* identification, may be explained by the assumption that they merely represented one of many mistimed and misplaced spawnings and might well have died immediately but for their respite under laboratory conditions.

I would like to express my thanks to numerous colleagues, notably Dr. E. Trewavas and Mr. P. H. Greenwood, who have been my patient *advocati diaboli* during this work.

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INFORMATION THEORY AND ITS APPLICATIONS TO FUNDAMENTAL PROBLEMS IN PHYSICS*

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THE scientific theory of information, developed during the past few years, has yielded some very important applications in the field of telecommunications, but it has also led to many interesting discussions about the fundamental definitions of experimental science. Among other things, it has obliged the physicist to re-examine the role of experimental errors and has required a complete re-appraisal of their actual importance.

Formerly, errors were usually considered as a secondary effect, a nuisance that could be neglected in most occasions, and which should be ignored by theory. The assumption was that errors could be made as small as might be desired by careful instrumentation, and played no essential part. This was the point of view of mathematicians discussing the axioms of geometry, and most physicists accepted, implicitly or explicitly, this kind of idealization. Modern physics has had to get rid of these unrealistic schemes, and to realize the unpleasant fact that errors cannot be made as small as one wishes, but must be taken into account as an integral part of the theory.

Errors, Uncertainties and Observations

Until the end of the nineteenth century, most scientists assumed that experimental observations could reveal the 'laws of Nature'; of course, observations were perturbed by all sorts of errors, but it was customary to generalize the imperfect data available and to formulate simple mathematical laws; these *exact* laws were supposed to govern the outside world, whether it could be observed in principle or not. For example, Newton's laws of mechanics and of universal gravitation were accepted as rigorous, even though they had been verified only within the limits of experimental error.

The first difficulties were encountered in connexion with statistical thermodynamics: How was it possible to derive irreversible thermodynamics from strictly reversible mechanical laws? There was also the problem of determinism, which was assumed to be proved by scientific investigations, although in practice it remained impossible to verify such a rule by any experimental device.

With Heisenberg's 'uncertainty principle', the importance of errors in observations came into the foreground. Physicists realized that it was impossible to measure accurately, and at the same time, a co-ordinate x and its momentum p_x, and that the corresponding errors were coupled by the relation:

$$\Delta x \,.\, \Delta p_x \geqslant h \qquad (1)$$

Any experiment measuring x with an error Δx perturbs the system and introduces an unknown change Δp_x in p_x, making its exact determination impossible. It is a fundamental and inescapable fact that an observation always creates a perturbation. If you have a physical system which is completely isolated and unperturbed, you cannot observe it. An observation necessarily requires a certain temporary coupling between the system and a measuring instrument; this coupling results in a perturbation of the observed system.

This general remark was given a precise statement in a law discovered by me, and called the 'negentropy principle of information'. It states that an observation yields a certain amount of information ΔI, that this information can be measured quantitatively, and compared with an inevitable increase in entropy ΔS in the measuring device during the experimental measurement. The net result is (in entropy units):

$$\Delta S \geqslant \Delta I \quad \text{or} \quad \Delta I + \Delta N \leqslant 0 \qquad (2)$$
$$\text{with } \Delta N = -\Delta S \qquad \text{neg(ative) entropy}$$

These conditions mean that a finite amount of energy ΔE must be degraded and changed into heat:

* Based on a series of five lectures delivered at King's College, London, during October 21–29, 1958. Work done under contract *Nonr* 255 (56).

$$\Delta E = T\Delta S \geqslant T\Delta I \quad (T, \text{absolute temperature}) \quad (3)$$

The definition of the quantity ΔI can be summarized in a simple way[1]: let P_0 be the number of equally possible cases before the measurement, and P_1 the number of such cases after the observation. Then, by definition:

$$\Delta I = k \ln \frac{P_0}{P_1} \quad (4)$$

where k is Boltzmann's constant. If the accuracy is very high, P_1 becomes very small and the amount of information is very large. Infinite accuracy, with infinitely small error, would mean an infinite increase in information; hence an infinite amount of energy ΔE is degraded, which is quite impossible[2].

A similar opinion has been expressed by Born[4,5] in a series of papers based upon the obvious fact that every method of observation has its limitations, making experimental errors unavoidable. This is, in a general way, what is stated more precisely in our conditions 2.

When extreme accuracy is required, a new restriction arises, which makes it even more difficult to make a measurement of very small distances. It may be shown (ref. 1, p. 235) that a very large amount of energy ΔE is needed for the observation of a distance x within a very small error Δx:

$$\Delta E \cdot \Delta x \geqslant \tfrac{1}{2}\hbar c \quad (5)$$

This very large energy ΔE is partly dissipated, according to the previous conditions 2 and 3, and when Δx becomes extremely small (smaller than 10^{-13} cm., for example), the new condition 5 requires an expenditure in energy very much higher than that which would result from equation 3.

The preceding conditions 3 and 5 can be explained in simple terms. It has been realized since the work of Ising that Brownian motion (thermal noise) sets a limit to the accuracy of observations. Thermal agitation involves energies of the order of kT per degree of freedom. For a reliable observation of one degree of freedom, an energy larger than kT must be used in order to overcome irregular motions of magnitude kT. If the observation is made on many degrees of freedom, it will require an energy proportional to T; this energy is degraded, and yields an increase of entropy ΔS independent of T. This is practically the mechanism underlying equations 2 and 3.

As for condition 5, a simple numerical computation shows[3] that the energy ΔE, translated into electron-volts, corresponds to the many millions of volts required to measure the cross-sections of particles having very small diameters, Δx; relation 5, in fact, is applicable to the synchrotrons or other powerful accelerators used for measuring the very small cross-sections encountered in collisions of atomic particles.

To sum up: an observation is an irreversible process, necessarily involving an increase of entropy in the measuring apparatus: the information obtained is paid for in negentropy. As Gabor has commented, "You can never get something for nothing, not even an observation". This remark has far-reaching implications, which will now be discussed.

The Objective World and the Problem of Determinism

In a brilliant discussion, Schrödinger has explained[6] how much we owe to the Greek philosophers, from whom we inherited many fundamental ideas. These concepts have been extremely useful, but we have now reached a point where we must revise them drastically. The scientist used to step back into the role of an external observer, and to assume the existence of 'a real, objective world around us', governed by accurate mathematical laws (the laws of Nature), according to which it would proceed unperturbed, whether we observe it or not.

The modern point of view is different: when we are not making any observation, it must now be admitted candidly we do not know what is happening; and when we make an observation, we certainly perturb the 'outside world', by some coupling between observer and the observed. So the assumption of accurate laws of Nature is gratuitous; it is a philosophical creed, but it is not supported by experimental facts. All we can prove is the existence of certain correlations: given the result of a certain experiment, we are able to predict (within certain limits) the possible outcome of a later experiment. This, however, does not require any objective outside world: that is an additional assumption which may provide a convenient model for most large-scale experiments, but the model is definitely wrong at the atomic or sub-atomic scale.

Bridgman has repeatedly emphasized the danger of introducing into our theories too many unmeasurable quantities. Sooner or later these unobservable concepts will have to be rejected, and this will often mean a very painful re-appraisal of actual facts and data.

In many cases, strict causality must be replaced by statistical probabilities; a scientist may or may not believe in determinism. It is a matter of creed, and belongs to metaphysics; physical experiments are unable to prove or to disprove it. This general point of view may be called the 'matter-of-fact' point of view.

Relations 1 to 5 above show that it is quite impossible to eliminate experimental errors completely. They are not only a practical limitation but also they represent an absolutely unavoidable feature of the experimental method. Laplace invented, more than a century ago, a demon who was supposed to know exactly the positions and velocities of all atoms in the universe, and to compute exactly the future evolution of the whole world. The present discussion constitutes an exorcism of Laplace's demon. Both the uncertainty principle and the negentropy principle of information make Laplace's scheme of exact determinism completely unrealistic.

In order to measure very accurately the initial positions and velocities of all the atoms in the universe, the demon would need an infinite amount of energy, according to equations 3 and 5. The exact determination of initial conditions is thus physically impossible.

The negentropy principle of information had already provided a definite answer to the paradox of Maxwell's demon; it also eliminates Laplace's demon without further discussion. Experimental errors cannot be made as small as one may wish, for they belong to the actual facts of experiment and must be included in the theory.

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PHOTOREACTIVATION OF NUCLEIC ACID FROM TOBACCO MOSAIC VIRUS

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SOME types of injury caused by ultra-violet radiation to systems containing nucleic acids *can be reversed by subsequent exposure to visible* light. Irradiated viruses cannot be directly photoreactivated; but, except for strains of tobacco mosaic virus, all those yet reported on can be reactivated by exposing recently infected hosts to *visible light*[1]. *In other words, when irradiation has* destroyed about 99 per cent of the initial infectivity of a preparation, only strains of tobacco mosaic virus have shown the same residual infectivity whether inoculated hosts are kept in light or in darkness. *Two explanations for their exceptional behaviour* are self-evident: (1) their nucleic acids may be exceptional in not undergoing the type of change that is reversed by visible light; or (2) the manner in which their nucleic acids is combined with protein may prevent them from undergoing the reversible changes. *A priori*, as the morphology of tobacco mosaic virus differs from that of photoreactivable viruses, the second explanation seemed more likely to be true. Also, there is evidence that the protein protects against ultra-violet radiation, for the nucleic acid needs much more irradiation to be inactivated to a given level when in the virus than when free[2]. That the manner of combination with protein, or the quality of the protein, also affects sensitivity to irradiation is shown by the fact that different strains of the virus inactivate at different rates when intact, although their separated nucleic acids are equally sensitive[3].

The discovery that preparations of the nucleic acid from tobacco mosaic virus can be infective[4,5] made it possible to test these alternative explanations. This we have done and found that nucleic acid irradiated when freed from its protein can be photoreactivated. This alone would not establish the fact that the protein protects against the reversible type of irradiation damage, for the protein might prevent visible light from reversing the damage. However, the point seems to be fully established by the fact, shown in Table 1, that nucleic acid separated from irradiated virus was not photoreactivated. The solution of tobacco mosaic virus was irradiated so that about 99 per cent of the initial infectivity was destroyed, and the residual was the same whether measured on plants kept in light or darkness. The nucleic acid was separated from the virus by the phenol method[5] and its infectivity compared with that of nucleic acid similarly separated from unirradiated virus. The relative infectivities of the two nucleic acid preparations were of the same order as those of their parent virus preparations, and were the same whether the test plants were kept in light or darkness after inoculation.

Table 1. FAILURE OF LIGHT TO AFFECT INFECTIVITY OF NUCLEIC ACID FROM IRRADIATED TOBACCO MOSAIC VIRUS (T.M.V.)

Inoculum	Dilution of the inoculum	Total number of local lesions obtained on twelve half-leaves	
		Dark	Light
Irradiated 1 per cent T.M.V.	1/50	401	416
Non-irradiated 1 per cent T.M.V.	1/2,000	783	860
	1/10,000	397	417
	1/50,000	132	139
Nucleic acid from irradiated 1 per cent T.M.V.	1/1	45	42
	1/5	10	7
Nucleic acid from non-irradiated 1 per cent T.M.V.	1/20	198	172
	1/100	38	23
	1/500	9	7

5 ml. of a 1 per cent solution of tobacco mosaic virus in *M*/60 *p*H 7·0 phosphate buffer were irradiated at 3,030 μW./cm.^{2} in a Petri dish of dia. 6·6 cm., so that 2·5 joules were absorbed and scattered per 1 mgm. The number of lesions obtained with the intact virus cannot be directly compared with those obtained with the nucleic acid, for they came from different tests on different sets of *Nicotiana glutinosa* plants. 'Dark' and 'Light' mean respectively that the plants were in darkness or daylight after they were inoculated.

Table 2. PHOTOREACTIVATION OF NUCLEIC ACID IRRADIATED WITH ULTRA-VIOLET LIGHT AFTER ISOLATION FROM THE VIRUS

Time of irradiation (min.)	Absorbed energy (joules per mgm.)	Dilution of inoculum	Number of lesions		$\log_{10}$ of remaining proportion of initial infectivity			
			Dark	Light	Found		Computed	
					Dark	Light	Dark	Light
1·25	0·63	1/1	297	722	−1·1	−0·53	−1·0	−0·5
3·5	1·76	1/1	11	194	−2·7	−1·4	−2·8	−1·4
0	0	1/5	596	543	—	—	—	—
0	*0*	*1/50*	*91*	*100*	—	—	—	—
0	0	1/500	12	7	—	—	—	—

The undiluted nucleic acid was a 0·66 mgm./ml. solution in *M*/60 *p*H 7·0 phosphate buffer, of which 2·5 ml. were exposed to radiation of intensity 870 μW./cm.^{2} in a Petri dish of dia. 4·5 cm. The log. of *the remaining proportions of the initial infectivity* were found from the curve obtained by plotting the numbers of lesions produced by the control preparation against the log. of their dilutions. The computed values were obtained from the equation $\log_{10} p = -kv$, where p is the remaining proportion of the initial infectivity, v is the energy absorbed in joules per mgm. and k is assumed to be 0·79 with photoreactivation ('Light') and 1·58 without photoreactivation ('Dark').

Nucleic acid preparations have only a small fraction of the infectivity per unit of phosphorus of intact virus and most of this must be destroyed to demonstrate photoreactivation. Hence, the test plants (*Nicotiana glutinosa* L.) must be highly susceptible, and ours were raised in shade and kept at 37° for a day before they were inoculated. Both these treatments increase susceptibility to infection by intact virus but do so much more when nucleic acid is the inoculum. Table 2 shows the results of an experiment in which two aliquots of nucleic acid made by the phenol method from a 2 per cent virus solution were irradiated to different extents, after which their infectivity was compared with that of unirradiated nucleic acid inoculated at three concentrations. The nucleic acid was kept at 0° between the time it was made and used as inocula, and samples were irradiated as thin layers in Petri dishes kept rocking in a bath of iced water. Twelve plants were used, and each

solution was inoculated to twelve half-leaves distributed equally on each plant and at each leaf position. After inoculation, six plants were exposed to daylight and six put in darkness. The greater relative infectivity of the irradiated nucleic acid in plants in the light is obvious. With or without photoreactivation, inactivation approximately follows first-order kinetics, with photoreactivation equivalent to halving the dose of radiation. This factor of two places the nucleic acid of tobacco mosaic virus second only to potato virus *X* when plant viruses are listed according to the extent they show photoreactivation[1], but as the other viruses were irradiated only when intact, their nucleic acids might show the phenomenon more strongly if irradiated free from their protein.

McLaren and Takahashi[2] found that the infectivity of nucleic acid preparations was halved when 1 mgm. absorbed 0·43 joule. They do not say how their inoculated plants were treated, but it is likely they were placed in the light, for this value is close to the 0·38 joule which can be calculated from the data in Table 2 for plants in the light, whereas the value for 50 per cent inactivation without photoreactivation is 0·19.

Siegel, Wildman and Ginoza[3] concluded that the differences between sensitivity of different strains of tobacco mosaic virus reside in the nature of the bonding between the protein and nucleic acid. As none of the strains yet tested, although they differ in their sensitivity to inactivation, shows photoreactivation when irradiated intact, all seem to share a type of bonding that protects the nucleic acid from changes reversed by light. We have not attempted to see whether recombining separated nucleic acid with the protein would prevent photoreactivation, but the type of bonding in 'reconstituted' virus particles seems to differ from that in the original virus because the recombination does not restore the original degree of resistance to inactivation by irradiation[4]. Even the most sensitive strain of tobacco mosaic virus requires much more energy to be inactivated than does potato virus *X*, which has the same content of nucleic acid. It seems, then, that the nucleic acids of different viruses may resemble one another in sensitivity to irradiation and in undergoing more than one type of change, but that their proteins protect them to very different extents from changes of different kinds. It is possible that we have not measured the full potential of tobacco mosaic virus to be photoreactivated, for separating the nucleic acid from its protein may have changed some of the groups that otherwise could have undergone reversible changes.

We used two low-pressure mercury lamps, both of which have most of their radiation of wave-length 254 mμ, and one of which had a filter excluding wave-lengths shorter than 240 mμ. Both gave qualitatively similar results: photoreactivation when the separated nucleic acid was irradiated, but not when intact virus was, whether the inoculum was intact virus or nucleic acid separated from the irradiated virus.

[1] Bawden, F. C., and Kleczkowski, A., *J. Gen. Microbiol.*, **13**, 370 (1955).
[2] McLaren, A. D., and Takahashi, W. N., *Radiation Res.*, **6**, 532 (1957)
[3] Siegel, A., Wildman, S. G., and Ginoza, W., *Nature*, **178**, 1117 (1956)
[4] Fraenkel-Conrat, H., *J. Amer. Chem. Soc.*, **78**, 882 (1956).
[5] Gierer, A., and Schramm, G., *Nature*, **177**, 702 (1956).

OBITUARIES

Sir Claude Gibb, K.B.E., F.R.S.

Sir Claude Dixon Gibb, who died suddenly in the United States on January 15, was one of the outstanding engineers of our time. He was also pre-eminent as an administrator, manufacturer and scientist. He was sixty years of age.

After qualifying at the University of Adelaide, he became a senior research assistant in the Engineering Laboratory there after a short interruption as a pilot in the Royal Australian Flying Corps. He went to Great Britain in 1924 to gain experience as a fitter with the firm of Messrs. C. A. Parsons and Co., Ltd. Such was his ability that he was made general manager in 1937 and managing director in 1943. In 1940, loaned by his Company to the Ministry of Supply, he rapidly moved from engineering assistant to director-general, Munitions Production, and afterwards to director-general, Armoured Fighting Vehicles, and chairman of the Tank Board.

He was elected a Fellow of the Royal Society in 1946 and has been noted for his particular interest in research, originally on steam turbine components and latterly in nuclear work for the production of power. In 1946 he was appointed a member of the Board of the National Physical Laboratory, and became a member of the Council of King's College, Newcastle upon Tyne, in the same year.

In 1947 Sir Claude was appointed a member of the Advisory Council on Scientific Policy and became chairman of the Committee on Research and Productivity. He has also been chairman of the Sectional Committee on Engineering of the Royal Society and was a member of the Mechanical Engineering Research Board of the Department of Scientific and Industrial Research. In 1949 he was a vice-president of the British Association and in 1951 president of Section *G* (Engineering) of the Association. He was also chairman of the Board of Governors of the Rutherford College of Technology.

Sir Charles's own scientific work has been described in technical papers given to the major institutions in Canada, Australia and the United Kingdom. Under him, Messrs. C. A. Parsons have an order for a 550 MW. set for the Thorpe Marsh Power Station—at this time the largest in the world. As a result of his work, this Company became the main contractors for the first nuclear power station, namely, Calder Hall. The Company has also been engaged in the very large items of equipment for Chapelcross Power Station and the large new power station under construction at Bradwell. Sir Claude was also mainly instrumental in the negotiations in Italy to build a nuclear power station at Latina, near Rome.

Sir Claude received many well-deserved honours. Such is the brilliant record of a man who from fundamental knowledge of science with a strong basis of practical imagination brought so much honour to the firm and country which he chose as his own.

T. W. F. Brown

Prof. W. Wardlaw, C.B.E.

THE very large number of scientists who knew him personally were grieved to learn of the death of Prof. William Wardlaw on December 19, at the age of sixty-six.

Wardlaw was educated at Newcastle upon Tyne, first at Rutherford College, and then at Armstrong College, in the University of Durham. Although he lived for a large part of his life in the Midlands and in London, he never forgot his connexion with Northumberland and often referred with pride to his early days in the North Country. In 1918 he joined the staff of the Department of Chemistry, University of Birmingham. He proved to be an admirable university teacher and progressed to the rank of senior lecturer in inorganic chemistry. He was appointed to the chair of physical chemistry in the University of London, tenable at Birkbeck College, in 1937, and he held his professorship for twenty years until his retirement in 1957, when the title of professor emeritus was conferred on him.

For more than forty years Wardlaw carried out valuable research in inorganic chemistry. During the early stages of his career he investigated some inorganic oxidation processes and made contributions to the chemistry of molybdenum. In the 1930's his interest turned to the stereochemistry of metal complexes. This subject continued to hold his attention for the rest of his life, and by his work he made an important contribution in this field of study. On taking up his appointment in London, Wardlaw had barely succeeded in getting his new department organized when the Second World War began and a halt was called to his research activities. At the conclusion of hostilities he was faced with two major tasks. He had to build up afresh a research group, and to plan and equip a new department, since his College was transferred to new quarters in Bloomsbury. He attacked both tasks with characteristic vigour. An extensive programme of research on the esters of transition metals was initiated, and under his direction a flourishing research school was developed in the new well-equipped laboratories. The results of this last phase of his research work have had an important influence on the development of modern ideas of the inter-relation of physical properties with molecular structure.

Wardlaw held strongly the belief that university scientists should not lead an 'ivory tower' existence, and he seized every opportunity to broaden the impact of chemistry upon the community. He sought to widen the range of contacts of scientists in the universities, in industry, and in research associations, and his membership of the Society of Chemical Industry dated from 1917. He was extremely sympathetic towards the difficulties which faced science masters in schools through poor laboratory accommodation, and often spoke up strongly on this point. Scientific publication interested him enormously, and he gave considerable thought to the best ways of dealing with the ever-increasing volume of chemical papers. To the professional societies he gave generously of his time and found much pleasure in this service. In later life he reached high office in these societies, but his many friends testify that his support was equally enthusiastic at the commencement of his career.

During the difficult period 1940–48, he was honorary secretary of the Chemical Society, and he became president for 1954–56. His first membership of the Council of the Royal Institute of Chemistry dates from 1929 and at the time of his death he was president. To be elected president of both the Chemical Society and the Royal Institute of Chemistry is an honour accorded to few, and is a measure of the esteem in which Wardlaw was held by his professional colleagues and the confidence which his sound judgment inspired.

He had strong sympathy with the aims of the British Association, and the active part he played in its affairs demonstrates his strong conviction that the chemist has responsibilities which extend beyond the boundaries of his profession. In 1952 he presided over the meetings of Section *B* (Chemistry) and more recently took office as one of the general secretaries. He was closely connected with the current developments in the activities of the Association.

During the Second World War Wardlaw was a joint secretary of the War Cabinet Scientific Advisory Committee, after which he became scientific advisor to the Committee of Appointments in the Ministry of Labour and National Service. Undoubtedly he had a flair for accurate judgment of character and ability, and his advice has been of great national benefit. In 1949 he was created C.B.E.

Wardlaw was always sympathetic to his students and ready to assist in their problems: they responded to his interest with a deep sense of respect and grateful affection. He could not bear slipshod work or laziness, and on occasion his comment and censure could be forthright.

Being a humorous man of much charm, he had a great many friends. His colleagues at Birkbeck College and throughout the University of London always welcomed his company and found joy in his unvarying friendliness. His devoted and wholely selfless service to learning, the public welfare, the advancement of science and the selection and production of scientists, add up to a life-time's work of inestimable value. Scientists, and especially chemists, owe a great deal to Wardlaw, and it is hard to realize that no longer will it be possible to call on his services or to seek his wise counsel.

In 1932 he married Doris Whitfield, who had herself been trained as a chemist, and he never failed to pay tribute to her sympathetic understanding and help in his work. She and their daughter survive him.

W. G. OVEREND

Prof. A. R. Fulton, M.B.E.

ANGUS ROBERTSON FULTON, emeritus professor of engineering and drawing in the University of St. Andrews, died at his home in Dundee on November 21.

Born in Dundee on June 23, 1871, he suffered the early misfortune of being left an orphan at the age of five. This affected his opportunities for education, but by courage and determination he acquired a training as an engineer. On qualifying, he worked for some years with Hurst and Nelson, of Motherwell, and it is a testimony to his ability that, although up to that stage he had no university degree, he was invited by Prof. T. Claxton-Fidler to be his assistant in the Engineering Department of University College, Dundee. He spent the rest of his professional life, from 1902 until 1946, on the staff of that Department.

He graduated B.Sc. in 1907, and was the main assistant, first, to Prof. Claxton-Fidler, then to his successor, Prof. A. H. Gibson. During the First World War he served for some time in the Royal

Flying Corps and worked as an investigator of accidents caused by mechanical failures. For this work he was mentioned in dispatches and was made M.B.E.

On returning to Dundee, he continued his researches on stresses in materials and received the degree of D.Sc. in due course. He was appointed professor of engineering and drawing in University College, Dundee, in 1920, and held this post until he retired in 1946. During 1939–46 he was also principal of University College, Dundee. In both posts he was highly respected by his colleagues for his academic abilities, for his powers as an administrator, and for his sincerity.

J. Dick

NEWS and VIEWS

Zoology at Cambridge : Sir James Gray, C.B.E., F.R.S.

Sir James Gray, who is to retire from the chair of zoology at Cambridge in September, has been one of the chief architects of the structure of modern British zoology. He and the men and women he has trained have been largely responsible for the growth of experimental zoology and for the replacement of comparative anatomy by studies of the living animal in zoological laboratories throughout the Commonwealth. After serving with distinction in the First World War, he returned to Cambridge as Balfour student and then as reader in experimental zoology ; his cytological researches during this period culminated in the publication of "Ciliary Movement" in 1928 and "A Textbook of Experimental Cytology" in 1931. The design and building of the new zoology laboratory at Cambridge during 1932–34 provided him with his first major administrative task and it is a tribute to his skill that few people who work there to-day would wish to change the building. He was appointed to the chair in 1937 at a time when his interests were moving away from cytology to the analysis of animal movement, and he pioneered the application of physical principles to many different aspects of this study. Until after the Second World War his work was perhaps not widely known to the world at large, but this was remedied in 1951 by a series of Christmas Lectures at the Royal Institution, which were afterwards published under the title "How Animals Move". Before, and even more after, the War he has been active in the wider spheres of administration, being president of the Marine Biological Association, twice on the Council of the Royal Society, a member of the Agricultural Research Council during 1942–47 and for many years a development commissioner and chairman of the Advisory Committee on Fishery Research. This year he is president of the British Association. As editor, almost from its inception until 1954, of the *Journal of Experimental Biology* he has made a notable contribution to clarity in the publication of scientific results. Altogether, his influence will continue to be felt in his subject for many years.

Prof. C. F. A. Pantin, F.R.S.

Dr. C. F. A. Pantin, who has been elected to succeed Sir James Gray as professor of zoology in the University of Cambridge, has been reader in invertebrate zoology in the University since 1937. After taking his degree from Christ's College, Cambridge, he was physiologist to the Marine Biological Laboratory, Plymouth, during 1922–29, and returned to Cambridge as Harding Lecturer and Fellow of Trinity College in 1929. His researches have ranged over a wide field of invertebrate zoology. During 1923–31 he published a series of papers which laid the foundation of our knowledge of amœboid movement ; in 1931 he established the role of calcium in the osmotic regulation of the body fluid of the marine worm *Gunda* (*Procerodes*). His analysis during 1934–36, of the physiology of crustacean muscle was the starting-point for extensive subsequent work on this tissue ; at this time also he became interested in the Coelenterata, the neuromuscular physiology of which he has continued to clarify in a series of papers since that date. On his appointment to the readership, he found time to study the terrestrial Nemertines, hitherto largely unknown in Britain. His experiments have been characterized by a clarity and simplicity which has made them the basis of practical courses in comparative physiology throughout the world ; his insistence on the need for a parallel study of structure and function has done much to unify the different approaches to the study of invertebrate animals.

Dr. Pantin was president of Section *D* of the British Association in 1951, Croonian lecturer of the Royal Society in 1952 and is now president of the Linnean Society. He has given much assistance and encouragement to marine biology overseas, particularly in New Zealand and Brazil. Since 1947 he has been editor of the *Quarterly Journal of Microscopical Science*. His wide experience and skill as a teacher will ensure the continuation of the high standards of zoology at Cambridge.

California Institute of Technology, Radio Observatory : Dr. J. G. Bolton

John Gatenby Bolton has been appointed the first director of the California Institute of Technology's newly established Radio Observatory, which is situated near Big Pine in the picturesque Owens Valley of California. Bolton, while a member of the Radiophysics Division of the Australian Commonwealth Scientific and Industrial Research Organization, was responsible for some of the pioneering discoveries in radio astronomy, notably of the existence of 'radio stars'. In 1947, he was the first to put an upper limit (8′ of arc) on the size of the previously reported source in Cygnus, to define its position with sufficient accuracy to be able to say it was in a region of the Galaxy distinguished by the absence of bright stars and nebulæ, and to point out that the radio noise from it was out of all proportion to the optical radiation. Soon after, in 1948, he announced the position of other point sources; made the first identification with an optical object—that in Taurus with the Crab Nebula, the remains of an old supernova ; and took some of the first steps in using the radio observations to throw new light on the structure of the Galaxy. With this background, it is not surprising that the research programme of the new Radio Observatory will be concerned prin-

cipally with studies of radio stars. The main instrument will be an interferometer consisting of two steerable parabolic reflectors, each 90 ft. in diameter and having a mesh covering suitable for use down to 3 cm. The reflectors are each mounted on bogies on 35-ft. gauge railway tracks running north–south and east–west, so that when the pair is used as an interferometer the spacing and orientation can be varied.

The Institution of Electrical Engineers : Mr. C. W. Speirs

Mr. Charles W. Speirs has been elected to honorary membership of the Institution in recognition of his contributions to the advancement of electrical science and engineering, and of his outstanding support for the work of the Institution, particularly of its Incorporated Benevolent Fund. Mr. Speirs studied at the University of Durham and in 1891 entered the works of Messrs. C. A. Parsons and Co. at Heaton as an engineering apprentice. In 1898 he joined the Morgan Crucible Co., Ltd., as engineer and technical adviser, remaining with that organization until his retirement in 1933. In 1944 Mr. Speirs made a substantial gift of land from his estate at Malden, accompanied by a notable endowment, to the Incorporated Benevolent Fund. These gifts, supplemented by the contributions of members to the 'Homes Fund', brought into being the residential estate for beneficiaries of the Fund known as the Chesters Estate.

Signor Luigi Emanueli : Faraday Medallist

Signor Luigi Emanueli (who, we regret to announce, died on February 17) has been awarded the thirty-seventh Faraday Medal of the Institution of Electrical Engineers for his outstanding contribution of inventions and new applications in the field of electrical cables, and particularly for the invention of the oil-filled cable. Signor Emanueli, who was born in Milan in 1883, graduated in electrical engineering from the Milan Polytechnic in 1906. He is vice-president of the Pirelli Company of Milan, where he started his professional life in 1907. He was elected a member of the Institution of Electrical Engineers in 1922. Signor Emanueli has been connected with numerous scientific inventions and applications in the electrical cable and the rubber industries including the oil-filled cable, universally known as the Emanueli cable, which represents a turning point in technical progress in this field.

Increased Grants for Universities in Britain

In a written answer in the House of Commons on February 9, the Chancellor of the Exchequer, Mr. D. H. Amory, said that the University Grants Committee has recommended that in consequence of unexpected increases in student members and also increases in costs, the recurrent grants to universities in Britain for the last three years of the quinquennium should be increased. Existing grants were fixed on the expectation that by 1961–62 the number of full-time students would rise to about 102,000. In the current academic year this estimate would be exceeded by at least 6,500 and by the end of the quinquennium the increase was likely to be even greater. Mr. Amory said he is satisfied that some further assistance should be given to the universities and stated that he proposed to ask Parliament to provide for an increase of £2,550,000 in the recurrent grants for 1959–60, £2,660,000 for 1960–61 and £2,720,000 for 1961–62, exclusive of the provision required to meet the improved salary scales announced on March 12, 1957.

Research on Fuel and Power in Britain

The Parliamentary Secretary to the Ministry of Power, Sir Ian Horobin, replied in the House of Commons on Monday, February 9, to a series of questions about fuel and power research. He said that the Scientific Advisory Council of the Ministry of Power is concerned with the co-ordination and development of research in the utilization of the fuel resources of Britain. The Council works under an independent chairman and includes representatives of the fuel and power industries, the Department of Scientific and Industrial Research, industry generally and the universities. Experimental work with liquid methane is being paid for by the British gas industry and the American interests concerned, and the total cost to the gas industry is estimated at £1·5 million. The National Coal Board has decided to terminate experimental work on underground gasification at Newman Spinney on the ground that present results do not justify further expenditure. Research on the production of gas from oil is being concentrated upon hydrogenation of oil, and a commercial plant to work initially on oil and later on coal has been commissioned by the Gas Council. The gas industry estimates that its consumption of tail gas and other refinery surpluses may increase, in terms of coal equivalent, from the present 500,000 tons to 2 million tons in 1965.

The Tropical Products Institute

The Tropical Products Institute is to become one of the research stations of the Department of Scientific and Industrial Research, following the decision to transfer the responsibility for the Institute from the Secretary of State for the Colonies to the Lord President of the Council, so that Commonwealth countries which have recently achieved independence, and thus no longer come within the scope of the Colonial Office, may still avail themselves of the services of the Institute. Support will continue to be provided by the Colonial Office, from the Colonial Development and Welfare Funds, for work of primary interest to the Colonies. The main objective of the Tropical Products Institute is to ensure the economic viability of the under-developed territories of the Commonwealth within the tropics, by improving the technology of industries that already exist and introducing new industries as a result of research into new uses for tropical plant and animal products (including waste products of existing industries). Particular attention will be directed to the needs for diversification in those territories which have a one-crop economy.

New European Nuclear Energy Project

The third international project in the programme of the European Nuclear Energy Agency for the development of nuclear power for peaceful purposes on a European basis has been approved by the Agency's Steering Committee. Six European countries, together with Euratom, will combine in a joint investigation of the use of high-temperature gas-cooled reactors for nuclear power stations and other applications. The new project, known as *Dragon*, will be based mainly on the construction of an experimental power-producing reactor, developing

several megawatts, at the United Kingdom Atomic Energy Authority's Research Establishment at Winfrith Heath in Dorset. The cost of the five-year programme of research and experiment is estimated at some £13·6 million. £10 million will be provided by the United Kingdom, Euratom (43·40 per cent each), Austria, Denmark, Norway, Sweden and Switzerland. The excess £3·6 million will be borne by the United Kingdom, which will retain ownership of the reactor and installations on conclusion of the *Dragon* project. The agreement inaugurating the project is expected to be signed at the Organization for European Economic Co-operation headquarters in Paris. Previous joint nuclear energy undertakings initiated by the European Nuclear Energy Agency comprise a twelve-country Convention setting up the European Company for the Chemical Processing of Irradiated Fuels (Eurochemie) with plant and laboratories under construction at Mol in Belgium; and a Boiling Heavy Water Reactor at Halden in Norway, in the operation of which five Organization member countries and the Euratom Commission are participating.

New Reactor to be Built at Windscale

A NEW low-power research reactor is to be built at Windscale, which is being expanded as one of the national centres for the development of gas-cooled reactors. The new reactor, to be known as *Hero* (hot experimental reactor of zero power), will cost about £1¼ million and will be built near the advanced gas-cooled reactor (*Agr*), on which work has already started. Its function will be to complement the work of *Agr* by making it possible to carry out measurements at low radiation-levels and to experiment with several alternative arrangements of fuel to obtain the best results. It will be completed early in 1961 and will be operated and studied by physicists of the Research and Development Branch of the United Kingdom Atomic Energy Authority at the Windscale laboratories. *Hero*, which will generate a few kilowatts of heat, will consist initially of a graphite structure 19 ft. in diameter and 19 ft. high, but an important feature is that it will be possible to dismantle it and rebuild it in a variety of ways. The graphite core will be contained in a steel vessel connected to a pipe circuit with pumps and heaters so that it can be operated at high temperature in carbon dioxide. It will, in fact, be the reverse of *Agr*, since the carbon dioxide gas will supply heat to the core instead of removing heat from it. The fuel will consist (as in *Agr*) of clusters of rods of uranium oxide sealed into beryllium cans, arranged in channels in the graphite in a regular lattice.

Advanced Gas-cooled Reactor Power Stations

IT is expected that from about 1965 onwards the reactors for nuclear power stations in Britain will be based on *Agr*, using uranium oxide fuel and beryllium instead of magnesium cans. This will permit higher operating temperatures and heat ratings and consequently will lead to greater efficiencies than can be achieved in the reactors now being built for the electricity authorities. The levels of radiation inside the reactors will be considerably higher. Two broad categories of problems are raised by these more severe conditions: those of reactor physics and those of reactor materials. The most important material problem is to develop fuel elements which can withstand high burn-up under the exacting conditions of high temperature and high flux, and the main purpose of the *Agr* prototype is to test various types of fuel at high power for prolonged periods (100,000 kW. of heat). It is essentially a fuel-element development reactor. The reactor-physics problems concern the behaviour of neutrons within the reactor. The high radiation-levels necessary in *Agr* for fuel testing and power production prevent the physicist from gaining access to the parts of the reactor which need most careful study. Sensitive techniques, however, are available with which it will be possible to carry out the necessary measurements at low radiation-levels in *Hero*. In addition, there are the problems of the kinetics and stability of highly rated reactors. *Agr* fuel is intended to remain in the reactor for a long time, building up very substantial amounts of plutonium. The reactivity of such a system is strongly dependent both on the fuel and moderator temperatures and on the isotopic content of the fuel, and careful study is therefore needed of the stability and control of such reactors.

Conservation Corps for Young Volunteers

ONE important purpose of the Council for Nature is to assist in the conservation of areas important to naturalists and country-lovers. The Council for Nature has embarked on a new venture and has started to organize a Conservation Corps for young volunteers. The volunteers will combine a holiday of manual work on a site needing attention with study of the natural history of the area under expert guidance. This scheme will achieve two ends: the education of young people in the principles of nature conservation, thus establishing a pool of future leaders for further studies in natural history; and the restoration and preservation of areas of special interest for future generations. This plan will require expenditure over the next five years of £25,000, and towards this the Carnegie United Kingdom Trust is making a provisional grant of £9,000 to be spread over the first three years. The response from other sources, particularly the larger industrial firms, has been encouraging and the Council is confident that the project will develop in its entirety. The Council has appointed as organizer of the Conservation Corps Brig. E. F. E. Armstrong, a retired officer of the Royal Engineers. His last Army appointment was concerned with the selection of young men and women for regular commissions, and since leaving the Army he has been warden at the Loughborough College of Technology. He has had considerable experience in the Boy Scout movement and Toc H and is also a keen naturalist.

Regiomontanus's Astrolabe at the National Maritime Museum

THE National Maritime Museum has recently placed on exhibition a small brass astrolabe made in 1462 by Johannes Muller, of Königsberg, known to posterity by his Latin name, Regiomontanus. This astrolabe was the first scientific instrument he made—it was a gift to his patron, Cardinal Bessarion, who had brought the young scholar to Rome from Nuremberg and given him access to his fine manuscripts on classical Greek astronomy. Later, Regiomontanus returned to Nuremberg and erected there an observatory, a press for printing scientific books and a workshop for making scientific instruments. It is this activity, spreading out from his centre, that

marked the rebirth of astronomy and the beginning of the Renaissance of science. The astrolabe is a circular star map that can be rotated so as to calculate the positions of the Sun and the stars at any time of any day of the year; it could also be used for simple observations. The style of the instrument and its special arrangement of star pointers were copied by later workers, and the exquisite craftsmanship pointed clearly the way of later precision instruments. The instrument was presented to Dr. William Somerville (husband of Mary Somerville, after whom Somerville Hall, Oxford, was named) in Rome; he gave it to his friend, Sir John Herschel. It has remained in the Herschel family ever since and has now been lent to the Museum by Commander M. H. Hardcastle, R.N.

Council of Europe Competition in Advanced European Research

A PRIZE of one million French francs is to be awarded every two years by the Secretariat-General of the Council of Europe for an original thesis of high academic standard on a given subject of European importance. It must not have been previously published, and must represent an original contribution on the subject set. The subject chosen for the first competition is "Consequences of the Use of Nuclear Energy for the European Mode of Life". Theses may be written in English, Dutch, French, German, Italian or Spanish, and entries must be submitted before the end of 1960. A jury, chosen by the Secretariat-General on the advice of the Committee of Cultural Experts of the Council of Europe, will award the prize. Further information can be obtained from the Secretariat-General, Council of Europe, Strasbourg, France.

Support for Institutes for Advanced Study in Science

THE North Atlantic Treaty Organization has established a fund to provide financial assistance to institutes and summer schools for advanced scientific study in those cases where a large degree of international participation is anticipated among both the faculty and the students. No precise pattern has been defined for eligible institutes, but it is expected that the programmes will normally last between two weeks and two months, will be at a postgraduate or higher level, and will provide for concentrated study of a restricted scientific field. It is hoped that this fund will encourage the establishment of institutes for advanced study similar to the highly successful summer schools of theoretical physics at Les Houches and Varenna, but in other scientific fields. Institutes and summer schools for advanced study in any of the natural sciences or technology may appropriately apply for grants. Although the eligible institutes must be situated in one of the fifteen member nations of the North Atlantic Treaty Organization, no nationality or other restrictions for either the staff or the students are in any way implied. Further information on the programme can be obtained from the Science Adviser, NATO Headquarters, Palais de Chaillot, Paris XVI, to whom applications for grants should be made.

Reform of the Calendar

A BRIEF review of the history of the calendar by Y. G. Perel (*Priroda*, 7, 47; 1958) suggests the urgent desirability of establishing a world calendar, such as was proposed by India in 1953 before the United Nations. According to this proposal, the year will be divided into four quarters of thirteen weeks each, with the first month of thirty-one days and the following two of thirty days each. An additional day (the day of peace and friendship) is added after December 30, and on leap years an additional day after June 30.

The Rockefeller Institute Press

THE Rockefeller Institute Press has been established to publish books on science and related subjects in association with the Oxford University Press, New York. Editorial responsibility for the books will rest primarily with the Institute, while Oxford will be chiefly responsible for design, printing and distribution. It is expected that the first books will be issued in the autumn of 1959. While many of the books and monographs will be the work of Institute faculty members, works by others will also be published. The Rockefeller Institute Press will be under the direction of Charles I. Campbell, administrative associate for information services at the Institute.

Lapis

Lapis, a monthly journal of industrial opportunities, the first number of which appeared in October 1958 (pp. 28. Subscription rates, including postage for one year: inland, £10 10*s*. 0*d*.; abroad, U.S.A. and Canada, 30 dollars; France, 15,000 francs; Italy, 19,000 lire. London: Kenneth Mason, 1 Old Burlington Street, W.1), lists patents available for disposal by licence or sale. These are classified in two parts: general, mechanical and electrical; and chemistry and chemical engineering. There is also a list of agents and agencies wanted. Details of patents for disposal and partnerships for development are sought from all over the world.

National Museum of Wales

THE annual report of the National Museum of Wales for 1957–58, after giving details of the personnel of Court, Council and staff, records that the third application to the Treasury for permission to establish a Department of Industry was granted. A sum of £2,000 was provided for this purpose. To supplement this an appeal for £5,000 has been addressed to local industrialists. The keeper of geology, Dr. F. J. North, acted as keeper of the new Department, and in addition to arranging a typical exhibit illustrating the development of the miners' safety lamp, was able to establish some useful contacts for the future. An impressive series of seventeen temporary exhibitions was arranged during the year. In the Department of Geology the emphasis has been on the reserve and study collections, while the chief task of the Department of Botany was to organize an exhibition illustrating paper and its uses. In the Glanely Gallery three cases, "Animals without Backbones", "Butterflies and Moths" and "The Main Group of Insects", were entirely re-arranged, while in the Department of Archæology reorganization has continued. In the Department of Art displays of Sheffield plate, the regalia of the Gorsedd of Wales have been added and other exhibits enlarged. The Welsh Folk Museum was chiefly concerned during the year with the re-erection of three houses from Cilewent, Radnorshire; Hendre'r-Wydd, Denbighshire; and Llandfadyn, Caernarvonshire. Such a record of progress in all Departments is a measure of the devotion of the staff of this Museum to the interests of the community.

1959 Waverley Gold Medal Competition

The Waverley Gold Medal and a prize of £100 will be awarded for an essay of about 3,000 words based on recent scientific research or development (whether the author's work or not), giving an outline of the scientific background, the experimental results and its potential application in industry. Essays will be judged for technical content, clarity of presentation and for style. A second prize of £50 will also be awarded; and an additional prize of £50 is offered for the best entry from a competitor under the age of thirty on July 31, 1959. The competition is open only to persons engaged in scientific work during January 1–July 31, 1959. Further details can be obtained from the Editor, *Research*, 4/5 Bell Yard, London, W.C.2, to whom all entries must be submitted before July 31.

Bell Telephone Laboratories: Kelly Award

Bell Telephone Laboratories and the American Institute of Electrical Engineers have announced the establishment of an award for achievement in the field of telecommunications, to be known as the Mervin J. Kelly Award. The award is named in honour of Dr. Kelly, formerly president and now chairman of the board of Bell Laboratories, who will retire on March 1 after forty-one years of scientific and administrative service with the Bell Telephone System (*Nature*, **183**, 221; 1959). The Kelly Award will be given annually by the American Institute of Electrical Engineers to an individual who has made an outstanding contribution to the advancement of telecommunications. The prize will consist of a bronze medal, a cash award of 1,000 dollars and a certificate. The first award will be made in 1960. The Award is being sponsored by Bell Laboratories but will be administered solely by the Institute.

"Electrode Potentials and Compound Formation in the Palladium–Platinum–Hydrogen System"

Referring to the communication under this title in *Nature* of January 3, p. 39, Messrs. A. W. Carson, T. B. Flanagan and F. A. Lewis write: "The platinum content of the palladium–platinum alloys investigated should be read as weight per cent. It had previously been reported (Stetsenko, A. I., and Tverdovskii, I. P., *Zhur Fiz. Khim.*, **26**, 647; 1952) that the upper limit of platinum content in palladium–platinum alloys, which allows of the formation of a two-phase region close to 25° C. in the palladium–platinum–hydrogen system, is about 9 per cent by weight platinum and not 5 per cent as incorrectly quoted by us".

Burden Neurological Institute: Dr. W. Ross Ashby

Referring to the note on the appointment of Dr. Ross Ashby as director of the Burden Neurological Institute, Bristol (*Nature*, January 24, p. 220), it has been pointed out to us that he will not be succeeding the retiring director, Prof. F. L. Golla, until May 1. Dr. Ross Ashby was referred to as "previously director of the Research Laboratory at Barnwood House, Gloucester"; he is in fact director of research at that Institute. For eleven years Dr. Ross Ashby was pathologist at St. Andrew's Hospital, Northampton. Among his publications is "An Introduction to Cybernetics", which has been translated into French, Spanish and Russian. In 1932 he obtained the Bronze Medal and Prize of the Royal Medico-Psychological Association, and in 1948 he obtained the Burlingame Prize (£100) offered by the Institute of Living, Hartford, Connecticut, for the best piece of original research carried out during the previous year. In 1956 he was granted a fellowship at the Center for Advanced Study in the Behavioral Sciences, Stanford, California.

Announcements

Prof. R. O. Redman, director of the Observatories in the University of Cambridge, has been elected president, for 1959–60, of the Royal Astronomical Society, in succession to Dr. W. H. Steavenson.

The Secretary of the United States Army, Mr. W. M. Brucker, has presented a replica of *Explorer* 1, the first American Earth satellite placed in orbit, together with its *Jupiter-C* carrier rocket, to the Smithsonian Institution.

Arrangements have been made by the British Council with the assistance of the Foreign Office, the Board of Trade and the Nuclear Energy Consortia for Prof. W. Murgatroyd, professor of nuclear engineering in Queen Mary College, London, to visit Venezuela, Colombia, Peru and Mexico during March 30–April 29. Under similar arrangements Prof. J. M. Kay, professor of nuclear power in the Imperial College of Science and Technology, London, is to visit Chile, Argentine, Uruguay and Brazil during March 23–April 29. They will lecture to scientists and engineers on British nuclear developments and aims, and also discuss the possibilities for future co-operation with the United Kingdom.

The Proceedings of the Fourth International Congress of Biochemistry, held in Vienna in 1958, are being published by the Pergamon Press by arrangement with the International Union of Biochemistry. The fifteen volumes include all the contributions, invited discussions, symposia and colloquia presented.

A debate, organized jointly by the Royal Institute of Chemistry (London Section), the Classical Association (London Branch) and the Haldane Society, on the motion "That the Education of our Future Rulers should be primarily in the Sciences rather than in the Humanities", is to be held in the Beveridge Hall, Senate House, University of London, on March 18. The chairman will be Sir Cyril Hinshelwood; for the motion, Sir Alexander Fleck and Prof. A. R. Ubbelohde; against the motion, Prof. B. Farrington and Prof. W. Beare.

The Plant Phenolics Group is holding a symposium on "Phenolics in Plants in Health and Disease" in the Department of Engineering in the University of Bristol on April 2 and 3. Further details can be obtained from the honorary secretary, Dr. T. Swain, Low Temperature Research Station, Downing Street, Cambridge.

The annual International Starch Convention organized by the German Cereal Research Station at Detmold is to be held in Detmold during April 21–23. It will be followed on April 24 by a special Convention to celebrate 75 years of potato research and also on April 24 and 25 there will be held at Detmold the first plenary session of the newly formed International Committee for the Standardization of Analysis of Starch and its By-products. Further information can be obtained from Dr. Eric Dux, Sichel Adhesives, Ltd., 6 Friar's Lane, Richmond, Surrey.

FUEL AND POWER IN BRITAIN

A DEBATE in the House of Lords on January 21 on fuel and power policy in Britain was opened by Viscount Hall, who questioned the policy of replacing the use of coal by oil, particularly at four of the new nuclear power stations, and also suggested that the nuclear power policy might need revision in view of the rate of development and the possibility of building stations that would rapidly be outdated. Replying for the Government, the Minister of Power, Lord Mills, said that current government policy is following the general lines endorsed by the Ridley Committee. He stressed the importance of the Scottish Gas Board's decision to construct a Lurgi plant in Fife for the total gasification of poor-quality coal; this has arisen from close co-operation between the National Coal Board and the gas industry. A similar plant is to be constructed by the West Midlands Gas Board to use deep-mined coal of poor quality, and as an outcome of co-operation between the refineries and the gas industry, surplus products from refineries are to be delivered to gas works and processed into town's gas. Coal still provides the bulk of the fuel requirements of Britain—more than 200 million tons a year—and he hoped that research and development will in due course create new demands for our indigenous coal resources. The Scientific Advisory Council of the Ministry, under the leadership of Sir Alexander Fleck, has been asked to study these possibilities.

In view of the present excess of supply over demand for coal in Britain, the Government has been strongly urged to reduce further the production of opencast coal, to restrict the increasing use of oil fuel and to scale down the nuclear energy programme. Lord Mills stressed the temporary character of the present shortage. As regards opencast coal production, the output is to be reduced by 3 million tons this year; further reduction would involve breaking contracts with an industry in which £27 million has been invested in plant for this purpose. The Government, however, does not agree that the use of oil, which now represents 15 per cent of the fuel consumption of Britain compared with 7 per cent before the War, should be restricted. This would be inconsistent both with the fuel policy of the country and with the Government's general policy of removing restrictions on international trade. The liquid methane imports mentioned by Lord Hall represent, he said, an experimental trial of the technical and economic possibilities. As regards nuclear power, Lord Mills regretted the suggestion for curtailing the programme to increase the market for small coal. Cheap and abundant power is the basis of a thriving and progressive economy. Thanks to the work of scientists and engineers, Britain leads the world in the use of nuclear energy for the generation of electricity, but we could only utilize that lead by developing an industry continuously advancing the applications of nuclear energy by designing and applying reactors and associated engineering works. This would lower capital and operating costs, to the ultimate benefit of users of electricity and, although great improvements had been made in power stations operated by coal, we should reach a stage when the cost of nuclear power would justify our programme. Any practical results from the fast breeder reactor, of the type being constructed at Dounreay, were probably 10–15 years away, and from *Zeta* still further, but they are all promising developments.

Production of phurnacite has increased to 600,000 tons a year, but there have been setbacks in the development of full-scale manufacture of the process for binding anthracite known as shape. The Coal Board is now completing a pilot installation for the underground gasification of coal at Newman Spinney, near Chesterfield, and it was hoped that gas from this installation would shortly be generating electricity in a small temporary power station erected there by the Central Electricity Board. The programme of the Board for 1958–63 would provide new installed capacity of 12,800 megawatts, of which 10,730 megawatts will be steam driven, including seventeen new stations and three extensions to consume 25–30 million tons of coal a year when in operation.

On the matter of costs the Paymaster-General, Mr. R. Maudling, said in the House of Commons, on the second reading of the Electricity (Borrowing Powers) Bill on January 20, that while the capital cost of nuclear power stations at Bradwell and Berkeley will be about three times that of a coal-fired station, that of Hinkley Point will be down to 2·5 times. The present calculation is that the Hinkley Point station, of which the capital cost will be £120 a kilowatt, as against £145 for the earlier stations, will be marginally slightly more economic than a coal-fired station operating in the same area. Assuming 5 per cent interest-rate, 20 years life for the plant and a 75 per cent load factor, he believes that by the earlier 'sixties the nuclear plant will be marginally more economical than conventional plant.

SECONDARY EDUCATION IN BRITAIN

THE Government White Paper, "Secondary Education for All: a New Drive"*, marks no real change of policy but gives some welcome assurance of continuity. The imminent but temporary decline in the school population is to be utilized to improve the quality of education, and the bulk of the new expenditure is to be concentrated on the secondary schools. By the mid-1960's the worst inadequacies of the schools will have been remedied. There will be more and better school buildings; more and better trained teachers; and smaller classes. The Government, however, considers it would be wrong to dissipate the improvement in educational standards to be secured under this immediate five-year programme by attempting too much too soon. The main objective is to encourage

* Secondary Education for All: a New Drive. Pp. 10. (Cmnd. 604.) (London: H.M. Stationery Office, 1958.) 9*d*. net.

those young people who wish to stay on voluntarily at school beyond the minimum school-leaving age and there is nothing in the White Paper about fixing dates for measures to extend the compulsory period of education. The programme is part of a concerted drive to create an educational system adequate to meet both national and individual needs in the modern world. The keynote is opportunity for the individual boy or girl to go as far as his or her keenness or ability will allow, and the nation must grasp the opportunity to develop the educational system so that it can better fulfil its task of producing citizens who are fitted by character, knowledge and skill to play their full part in an increasingly educated and responsible democratic society.

Before outlining the specific programme, the White Paper points out that the Government does not wish to rule out experiments with comprehensive or similar schools proposed on genuine educational grounds, but is convinced that it would be wrong to abandon the grammar schools, though they alone cannot provide sufficient numbers of highly trained citizens. There is still plenty of room for experiment in the precise pattern of organization to be adopted. The widest possible range of opportunities should be provided for boys and girls of different capacities and fitness, but it is wrong to think that each school can do everything or that each type of school must have a fixed and self-contained exclusive territory.

As a first step the Government proposes to launch and carry through a continuous building programme for primary and secondary schools, rising from £55 million in 1960–61 to about £60 million in 1961–62 and costing £300 million in the five years to 1964–65. An immediate increase is being made in the volume of minor works which local education authorities and school governors can undertake, and the limit of cost is being raised from £10,000 to £20,000. The reorganization of the remaining 'all-age schools' in which are more than 150,000 pupils of eleven or more is to be completed, and resources will also be found for improving conditions in existing secondary schools. Reference is made to the improvement of science facilities, and although it is not expected to bring all secondary school buildings up to modern standards, by concentrating first on the tasks that will most quickly yield improvements it is hoped to make a big advance towards secondary education for all within the five-year programme. As regards the reduction in the size of classes, the Government's policy is first to increase the supply of teachers, and apart from the expansion of teacher training colleges already announced the Government's policy is to increase recruitment from universities also as far as is consistent with the maintenance and improvement of quality. It is determined that the size of primary classes should continue to be reduced as quickly as possible so that classes of more than forty children are virtually eliminated by the middle-1960's. A decisive general improvement in secondary school classes is also expected within the next five years. The White Paper includes a useful summary of progress under the Education Act of 1944.

THE COUNCIL FOR SCIENCE AND TECHNOLOGY OF WESTERN GERMANY

AN important event during the past year was the foundation of the *Wissenschaftrat* (Council for Science and Technology) in Western Germany. It was constituted on February 8 with the Federal President himself taking the chair, following a proposal by the president of the German Research Association (*D.F.G.*), Prof. Hess. Previously, at its annual general meeting, the Industrial Donors' Association had already welcomed the idea and stood squarely behind it from the outset. The tasks of this new body are as interesting from a purely practical as they are from an idealistic point of view. Just as interesting is its composition, reflecting all sections of academic, public and industrial life, with members who may be expected to take a large and important share in research, university teaching and training, and the application of pure and applied research in industry and commerce. The academic element, as is traditional in Germany in such matters, is in the majority—sixteen professors, all prominent nominees of the German Research Association, the Max Planck Society and the Committee of German Vice-Chancellors (*Rektorenkonferenz*). In addition to this academic core, the Federal and Land Governments delegate jointly six members, and the Federal Government alone six further leading Civil servants. The latter represent the Ministries of the Interior, Finance, Economics, Food, Transport and include a Secretary of State from the Ministry for Atomic Energy and Waterpower. Also the *Länder*, the highest education authorities, including universities, are themselves represented at ministerial level, by one delegate each, including Berlin, thus adding nine members. This adds up to thirty-seven, to which the industrialists as sponsors and donors (*Stifterverband für die deutsche Wissenschaft*) also send their honorary president and curator and six further members.

These forty-five men forming the new Council are thus a significant mixture of prominent personalities and well qualified, it would seem, to deal with their brief. This was summarized in the *Bulletin Wirtschaft and Wissenschaft*, published in the spring of 1958:

(1) The reflexion to the outside world of the unity and equality of all science, that is, of the equal importance of research, teaching and training in Germany. This Council could be described as the 'scientific conscience of the nation'.

(2) The Council will have to assess and determine the total requirements of the three tasks, research, teaching, and training, covering the whole federal area.

(3) The Council has to hold a watching brief over a proper flow of young men of promise from university institutions, industry, public life, into positions of responsibility and leadership.

(4) Reforms and developments have to be taken care of, with regard to all three aspects mentioned above, and the financial implications to be worked out in collaboration with the Ministry of Finance.

(5) A key to apportioning financial liabilities among Federal and Land governments has to be found, possibly on a quinquennial basis. (The latter point recalls the five-year period in the fiscal commitments

of the Treasury in Britain, through the University Grants Committee, and it is not improbable that the German suggestion was influenced by the British example. There is ample evidence that the latter was carefully studied.)

(6) The Council will have to smooth out inequalities and co-ordinate measures taken by the central and local governments (*Länder*, cities and districts), as regards the promotion of interest in science and research.

(7) Finally, it will be the Council's duty to scrutinize a proposal to create a central agency for the promotion of science, scholarship and research, under a federal ministry.

This is only a brief statement of the main aims for which this Council was called into being. Conditions for its proper functioning will, of course, be :

(1) The provision of adequate grants for supra-regional research institutions and projects, from the central Government and the land authorities, inasmuch as the latter cannot adequately finance them.

(2) The willingness of *Länder* governments to supplement federal funds in financing certain regional institutions.

(3) The readiness of industrial and commercial organizations to give larger sums than hitherto for the general promotion of science and for scholarships, over and above those which benefit industry directly.

(4) Parliament will have to strengthen and support the Council by accepting its advice and legislating in the light of this advice. The Council should in time achieve considerable public importance, comparable to that of the University Grants Committee.

(5) Finally, the Council should devise broad reforms for staff–student relations in institutions of higher education, for only this can ensure the vigilance necessary for 'talent-spotting' in the future.

Perhaps the most important of these points is Parliament's job of budgeting for developments in science, scholarship and technology. The first step has already been taken : annual returns have been abandoned in favour of five-year plans. A carry-over of unspent funds must obviously be permissible. Altogether, a generous, non-bureaucratic attitude seems to have been emphasized from the outset, as befits a body composed of representatives drawn from so many sources.

All members of this new Council are aware that they have to make up a good deal of lost time and, for the sake of their country's great tradition in research and scholarship, they are anxious to regain a new leading place in international science.

J. HORNE

PHOSPHATES AND ORGANIC SUBSTANCES IN NITROGEN DEFICIENCY

THE International Association for Research on Phosphates, with its headquarters at 28 rue Saint-Dominique, Paris VII^{e}, held its third congress at Biarritz during October 21–24. Approximately one hundred scientists and chemical engineers from twenty-three countries attended the Congress, which which was on the greater utilization of phosphates.

Communications on mining phosphate rocks, their solubility, residual effects in soils, influence in plant growth and value when incorporated with organic substances were read and discussed.

Drs. L. Schmitt (Darmstadt, president of the Association), F. Van der Paauw (Gröningen), F. Scheffer (Göttingen), L. Gisiger (Liebefeld, Switzerland), Ed. Hofman (Weihenstephan, Germany), L. Wiklander (Uppsala) and G. Barbier (Versailles) considered different aspects of the solubility of natural rock phosphates when added to soils and the phosphates present in soils under various conditions.

Drs. J. Cuzin (Paris, secretary of the Association), A. Fardy (Athens), Mme. Bireska (Warsaw), Drs. S. Nicolic (Belgrade), K. Nehring (Rostock) and M. Homes (Brussels) presented their observations on drop growth fertilized by different sparingly soluble calcium phosphates and phosphate rocks. Dr. O. Arrhenius (Grödinge, Sweden) reported a favourable effect on growth of trees when fertilized by powdered rock phosphates at the rate of one kgm. per tree.

All over the world there is a tendency towards a greater utilization of basic slag, phosphate rocks and strongly heated phosphate rocks instead of superphosphate and other soluble phosphates. This is certainly good for permanent agriculture, because the basic calcium phosphates leave a greater residual effect in soils and decrease the leaching of lime from the land. Dr. G. W. Cooke (Rothamsted) reported a more marked gain in the phosphate status of land when treated with bone meal than when superphosphate was utilized in the Saxmundham experiments over fifty-six years. It is of interest to note in this connexion that Dr. S. Nordengren (Landskrona, Sweden), the leader of the superphosphate industry in Sweden, is considering the manufacture of under-acidulated superphosphate and triple superphosphates for the market.

Interesting experiments on the solubilization of rock phosphates by the action of soil micro-organisms were described by Drs. L. Meyer and Eva Köning (Hohenheim-Stuttgart) and Dr. J. Pochon and Mlle. A. Roche (Pasteur Institute, Paris).

Dr. N. R. Dhar (Allahabad) discussed the augmentation of atmospheric nitrogen fixation in soils by incorporating different phosphates, with organic substances like green manure, farmyard manure, straw, municipal waste, leaves, grass sods, sawdust, legumes, or finely divided coal dust ploughed into the soil. He also reported that when basic slags, phosphate rocks or superphosphates are added to these organic substances during the process of composting, there is more fixation of atmospheric nitrogen in light than in the dark, and that the total nitrogen contents of the phosphated composts vary from 1·6 to 2·4 per cent as against 0·6–1 per cent present in the Indore composts of Howard. In this connexion it is interesting to record that Dr. L. Borasio (Vercelli, Italy) obtained good results in rice cultivation with a mixture of powdered rock phosphate and farmyard manure. Similar observations were described by Drs. E. Bottini (Turin) and A. Zeller (Vienna).

Recently the Soil Association at Haughley (England) obtained a yield of 30·4 cwt. of barley grain per acre by ploughing in 99 lb. phosphate per acre as basic slag mixed with barley straw. The yield with 112 lb. nitrogen as ammonium sulphate added to the same amount of straw was 20·8 cwt. per acre and in the control field containing only straw the yield was 14 cwt. per acre.

That phosphates and organic matter can fix atmospheric nitrogen in the soil and supply available nitrogen, phosphate, potash, humus and trace elements is of supreme importance in meeting the nitrogen shortage in the world (see *Nature*, **164**, 597; 1949).

The food production in the world is estimated to be approximately 1,100 million tons, for feeding the 2,700 million people. Out of this food, about 650 million tons consist of cereals (producing 1,100 million tons of straw containing 7–8 million tons of nitrogen) and 450 million tons of other foodstuffs. As only 25 per cent of the added nitrogenous fertilizers and manures is normally recovered in crops, and the average nitrogen content of the food materials is 2 per cent, approximately 110 million tons of fixed nitrogen seem to be necessary for the food production of the world. But chemical industry is supplying only 7 million tons per year (Table 1).

Table 1. World Production and Consumption of Fertilizers, 1955–56

Region	Production (1,000 tons)			Consumption (1,000 tons)		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Western Europe	2774·8	3352·0	3055·9	2248·9	3112·9	2639·9
United States	2033·0	2252·0	1735·0	1714·4	1989·3	1677·1
Eastern Europe	1222·7	1341·8	2113·0	1263·8	1405·9	1502·4
Far East	843·2	402·1	—	1145·0	411·9	428·3
Elsewhere	513·9	1096·5	12·1	591·2	1230·2	422·3
World total	7387·6	8444·4	6969·3	6969·3	8150·2	6670·0

It has been estimated that 4,000 million acres of land are available for cultivation in the world, and of this only 1,000 million acres are considered as first-class land. Consequently, if the fertilizers consumed in the world were evenly applied to the 4,000 million acres, each acre of land would receive 3·5 lb. nitrogen, 4·05 lb. phosphorus pentoxide and 3·3 lb. potassium oxide per year. It is an interesting coincidence that the fertilizers consumed in the United States per acre in 1956–57 are of the same order, that is, 4·2, 4·6 and 4·0 lb., respectively. Evidently these amounts are inadequate for intensive cultivation.

Moreover, the industrially under-developed countries find it difficult to construct nitrogen fixation factories. Table 2 shows the capital cost involved in the different types of ammonia synthesis plants for manufacturing 100 tons of ammonia per day.

Table 2. Capital Investment (Dollars) for Different Types of Ammonia Synthesis Plants

Natural gas	Fuel oil	Coal	Coke oven gas	Catalytic reformer gas
3,950,000	4,098,000	4,248,000	3,620,000	2,980,000

In a study on "Observations on the Planned Provision of Nitrogen Fertilizer", Prof. Tinbergen and others of the Netherlands Economic Institute, Rotterdam, have reported that the world demand for nitrogen fertilizer in 1960–61 is expected to be 3·1 million tons (Europe, 3·1 million tons; United States, 2·4 million tons; other areas, 2·6 million tons). They also concluded that the consumption of nitrogen per acre of land is directly proportional to the population density of the country. This is shown in Table 3.

Table 3. Nitrogen Consumption in 1956–57 in kgm. per Hectare per Year

Japan	109·6	Greece	12·1
Taiwan	86·7	Austria	11·5
Iceland	85·9	Portugal	10·5
Holland	79·0	Switzerland	10·1
Korea	54·1	Poland	10·0
Belgium	52·5	Spain	9·5
Norway	38·1	Philippines	5·6
West Germany	35·1	Czechoslovakia	5·0
East Germany	31·6	United States	4·2
Denmark	29·6	Ireland	3·2
Luxembourg	28·0	China	2·3
United Kingdom	23·5	Indonesia	2·0
Sweden	22·4	India	1·0
Ceylon	18·4	Turkey	0·4
Italy	14·7	Pakistan	0·3
France	14·4		

The average of the Organization for European Economic Co-operation area is 16·8 kgm. per hectare. It has been reported that there is shortage of chemical fertilizers in the U.S.S.R. The figures for nitrogen consumption in Table 3 show that, except in Japan, Taiwan, Belgium, Iceland and Holland, the nitrogen supply to crops as fertilizers is low. Only the countries having a large population density are compelled to use large amounts of industrial nitrogenous compounds, but not enough phosphates are used for producing the required amount of cereals. Moreover, in a recent publication (1957) on "Industrial Uses of Nitrogen" by the European Productivity Agency the following lines occur: "As world nitrogen production is outstripping the expansion of demand for traditional purposes (particularly for nitrogenous fertilizer), all producers are looking round for new outlets". It appears, therefore, that due to the high cost of nitrogenous fertilizers, farmers find it uneconomical to use the required amounts of chemical nitrogen for crop production.

The other nitrogen sources are legumes, precipitation, farmyard manure, municipal refuse and garbage. It has been reported that in the United States two million tons, and in the whole world five million tons, of nitrogen are fixed by the legumes in the soils of the Earth. Rain, snow and hail supply about 4–5 lb. per acre, that is, about 10 million tons of available nitrogen fall on the 4,000 million acres of agricultural land in the world, but a good deal is wasted as run-off. According to the U.S.A. Department of Agriculture, the world produces 1,400 million tons of manure containing 7–8 million tons of combined nitrogen, but only 15 per cent of this is actually utilized in cultivation. All over the world there is an attempt to prepare composts from city refuse and sewage sludge, which contain approximately 5 million tons of total nitrogen per year, but only a very small amount is actually reclaimed at present.

As the world reserves of phosphate rocks are not less than 21,000 million tons (United States, 7,000 million tons; U.S.S.R., 6,500 million tons; North Africa, 5,000 million tons; other areas, 2,500 million tons) and the annual consumption has been estimated to be 30 million tons by R. Saint Guilhem, technical director-general of the North African Phosphate Company, the natural rock phosphates should, at the present rate of consumption, last for at least 700 years. Consequently, a much greater application of these phosphatic materials, and basic slag from the expanding world steel industry, mixed with organic waste, would be of great value to permanent agriculture in all parts of the world.

N. R. Dhar

MEASUREMENTS AT LEEDS FOLLOWING THE WINDSCALE REACTOR ACCIDENT

From the Department of Medical Physics, University of Leeds, The General Infirmary, Leeds, 1

Iodine-131 in Human Thyroids and Iodine-131 and Cæsium-137 in Milk

By Dr. P. R. J. BURCH

FOLLOWING the announcement of the Windscale reactor accident of October 10, 1957, an apparatus was assembled to measure the trace uptake of iodine-131 in human thyroids and the concentrations of iodine-131 and cæsium-137 in milk.

A 4-in. dia. × 2½-in. sodium iodide (thallium) crystal was optically coupled to a 5-in. diameter photomultiplier, the output from which was fed via a cathode-follower and a linear pulse-amplifier to an *Mk I* 'Sunvic' pulse-analyser operated on its 60-channel range. The resolution obtained for the cæsium-137 photopeak was 14 per cent. Measurements were made inside a steel room, with walls and ceiling 9 in. thick, and a 12-in. thick floor, affording excellent attenuation of local γ-rays. The crystal-photomultiplier assembly was mounted on a bracket of adjustable height, and in the thyroid investigations the centre of the crystal was placed opposite the thyroid of the seated subject, so that the spacing between the crystal casing and the anterior skin surface over the thyroid was within the range of 1–2 in. Short separations were chosen to give the requisite high sensitivity, although this involved a sacrifice in calibration accuracy due to the uncertainties in the size and exact location of the thyroid. Calibration was performed at various separations with a mock thyroid, consisting of an iodine-131 solution in a glass bottle inserted in a wax 'neck' between the head and trunk of a water-filled 'phantom'.

Detailed γ-ray spectra over the energy-range 0·05–1·0 MeV. were taken in several cases, but due to the time-consuming nature of this operation it was not possible to employ it throughout, and in the remaining cases only the total count-rate for the energy-range 0·05–1·0 MeV. was recorded. Corrections for the contribution given by the cæsium-137 and potassium-40 contents of the body were deduced from detailed spectra. From experiments with a phantom, it was estimated that the count-rate from iodine-131 distributed through the body was less than 1 per cent of that from the thyroid, and consequently this small correction was ignored.

The results for the iodine-131 contents measured in human thyroids are summarized in Table 1 and the series of observations for subjects *A* and *B* are plotted in Fig. 1.

For the milk measurements, 1-pint bottles were clamped in a standard position against the end of the crystal casing, the axis of the bottle being at right angles to the crystal axis. Detailed γ-ray spectra were observed for a few samples, and corrections were derived for the potassium-40 contents of milk and bottle. The following response-rates for the energy-range 0·05–1·0 MeV. were determined: potassium-40 content of milk and bottle, 0·8 c.p.s.; 1·0 nc. (1 nc. = 10^{-9} curie) iodine-131, 3·6 c.p.s.; 1·0 nc. cæsium-137, 2·6 c.p.s. In the early samples the cæsium-137 contribution to the total counts was small compared with that from iodine-131 (Table 2); in the later samples, potassium-40 and cæsium-137 contributed, on the average, approximately 1 c.p.s. Where the cæsium-137 content was not directly determined from the detailed spectrum, the iodine-131 content was calculated by assuming that potassium-40 and cæsium-137 jointly contributed 1 c.p.s.

The milk results are summarized in Table 2, and the results for suppliers—one of the Leeds multiple dairies and the farm at Farsley—are plotted in Fig. 2. For the period October 16–25 the decrease of the iodine-131 content in milk samples from these suppliers was roughly exponential (there is evidently some alteration in the routine for milk delivered on a Saturday from the first suppliers) and the effective 'half-period' was approximately 3 days. Over the period October 26–November 13 the decrease in content was less rapid, the effective 'half-period' for samples from the above two suppliers being approximately 5·5 and 5·2 days, respectively.

The results are too few and too scattered for reliable generalizations concerning the iodine-131/cæsium-137 ratios in milk. The average for samples delivered on October 16 and 17 was 16 with extremes of 6 and 50. On November 6 and 7 this average ratio had fallen to 2·9. If the change in ratio had been due simply to the difference in physical decay of the two nuclides, the expected ratio on November 6 and 7 would have been 2·6.

This increase in cæsium-137 intake above that due to world-wide fall-out should have produced a significant increase in the body burden and this was, in fact, observed. In early 1957, the total body burden of cæsium-137 in subject *A* was 4·9 nc., but on April 1, 1958, this had risen to 11·5 nc. Assuming an effective half-life of 140 days[1] for

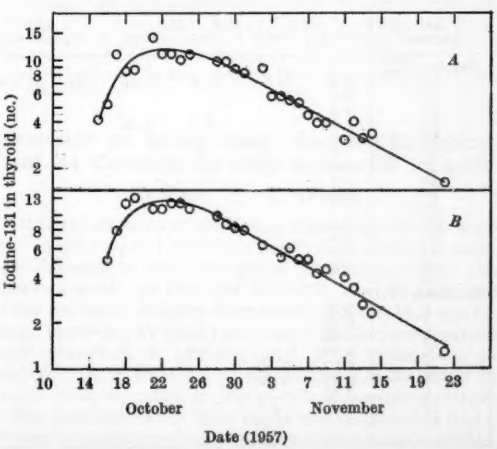

Fig. 1. Iodine-131 contents (nc.) of subjects *A* and *B* versus date

Table 1. Iodine-131 Content of Thyroid (in nc.)*

Date of measurement	Subject A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
October 1957																				
15	4·1																			
16	5·2	5·1	26	3·3	4·8															
17	11	7·9				2·6	2·2	24	4·1											
18	8·4	12								2·7	3·0	3·9	9·0							
19	8·6	13																		
20														14						
21	14	11	26												16					
22	11	11																		
23	11	12														23				
24	10	12																2·7	2·2	
25	11	11																		
27														12						
28	9·8	9·8																		
29	9·8	8·6	21	9·3																
30	8·7	8·2											8·3							
31	8·2	7·9																		
November 1957																				
2	8·8	6·3												6·5					10	
3	5·8																			1
4	5·8	5·3																		
5	5·5	6·0																		
6	5·3	5·1																		
7	4·4	5·1																		
8	3·9	4·1																		
9	3·9	4·4																		
11	3·0	3·9																		
12	4·0	3·3																		
13	3·1	2·6																		
14	3·3	2·3																		
22	1·6	1·3																		
January 1958																				
10	0·02	0·02																		

* 1 nc. = 10^{-9} curie

A Leeds resident. Intake of approximately 1·2 pt. *MA* milk daily.
B Leeds resident. Intake of approximately 1·2 pt. *MA* milk daily.
C Spent October 12, 13, 19 and 20 at Skipton (*MG* milk), remainder of time in Leeds.
D Leeds resident. Some *MB* milk in tea but mostly *MC*.
E Leeds resident. Approximately ½ pt. *MB* milk daily.
F October 11 Bristol, October 12 and 13 Surrey, October 14 p.m. Leeds, October 15 South Shields, October 16–17 Leeds.
G London until p.m. October 16.
H At Skipton with influenza until p.m. October 16. Milk from local farm.
I Leeds resident. Approximately ¼ pt. milk daily.
J Lake District. Keswick area until October 17 p.m.
K Lake District. Keswick area until October 17 p.m.
L Manchester resident. Milk from Chester area.
M Ilkley resident. About ¼ pt. *MF* milk daily.
N Four-year-old Leeds boy. Approximately 1·2 pt. *MA* milk daily.
O Cookridge, Leeds resident. Milk from local farm.
P Leeds resident. About 1 pt. *ME* local farm milk daily.
Q Polish visitor. Arrived Leeds October 22.
R Polish visitor. Arrived Leeds October 22.
S Leeds resident. Intake of approximately 1·2 pt. *MA* milk daily.
T Resident in Cambridge until November 2 p.m.

For explanation of abbreviations see Table 2.

cæsium-137 in the body, it is estimated that there should have been an increase on this date of about 5 nc. due to the additional intake of cæsium-137 from the Windscale incident, through milk alone. Over the same period, the cæsium-137 body burden of subject *B* rose from 7·9 nc. to 19·5 nc.

Fig. 1, showing the initial rise and subsequent fall in the iodine-131 contents of the thyroids of subjects *A* and *B*, reveals clearly the connexion with the Windscale incident. Iodine-131 has been detected in human thyroids after nuclear weapon tests[2]; but the maximum uptake observed was of the order of

Table 2. Iodine-131 and Cæsium-137 in Milk. (Results in nc. per pint)*

Day delivery	*MA* ^{131}I	^{137}Cs	*MB* ^{131}I	^{137}Cs	*MC* ^{131}I	^{137}Cs	*MD* ^{131}I	^{137}Cs	*ME* ^{131}I	^{137}Cs	*MF* ^{131}I	^{137}Cs	*MG* ^{131}I	^{137}Cs
October 1957														
16	6·6	0·3	20·6	0·75	3·2	0·4								
17	5·0	0·1					6·3	1·0	11·5	0·8	12			
18	4·4													
19	7·4		6·4	0·55										
20	1·7													
21	1·9								4·4				10·8	
22	1·3								3·1					
23	1·9								2·8					
24	1·4								2·3					
25									2·4					
26	3·4													
27	0·9													
28	0·8								2·0					
29	0·6								1·5					
30														
November 1957														
2	0·34													
3	0·33													
4	0·39													
5	0·40													
6	0·27	0·08												
7	0·22	0·09												
8	0·37													
13									0·18	0·1				
18									0·05	0·08				

* nc. = 10^{-9} curie. *MA*, a Leeds multiple dairy; *MB*, a Leeds multiple dairy; *MC*, farm, Cookridge, Leeds; *MD*, farm, Menston, Leeds; *ME*, farm, Farsley, Leeds; *MF*, farm, Ilkley; *MG*, farm, near Skipton.

10^{-10} c., in contrast with the maximum uptake of the order of 10^{-8} c. reported here.

Where the intake of iodine-131 from milk can be estimated, a close association with the uptake of iodine-131 in the thyroid is observed. It is interesting to note that subjects *J* and *K*, who had been in the Keswick area of the Lake District until October 17, had appreciably lower iodine-131 uptakes than Leeds residents—an illustration of the effect of wind directions during and after release of activity from the pile. Subject *T*, who until the afternoon of November 2 had been resident in Cambridge, had a thyroid content of less than 10^{-9} c. iodine-131 when measured on November 3.

An attempt was made to estimate the fraction of iodine-131 taken up by the thyroid of subject *A* and its effective half-life, by relating the observed uptake to the estimated intake through milk. (Although milk was undoubtedly the main source of iodine-131, it is possible that it was not the only one.) Reasonable agreement (Table 3) was obtained for a thyroid uptake of 44 per cent and an effective half-life for iodine-131 in the thyroid of 7 days. Both figures are rather high for a normal subject, but the exact intake of milk was somewhat uncertain and, furthermore, the response was sensitive to the thyroid-detector geometry. However, a value of 8·5 nc. measured for this subject on November 1 at the Radiological Protection Service, Sutton[3], is slightly greater than the value of 7·5 interpolated from the smooth curve of Fig. 1 (although a straight line drawn through the points for Octobe. 31 and November 2 intersects the ordinate for November 1 at 8·5 nc.).

The dose to subject *A*'s thyroid tissue was calculated by performing a numerical integration for the period October 13–27 and assuming that the decay of activity from October 28 to infinity was exponential, with an effective half-life of 9·6 days. Assuming a thyroid mass of 30 gm. and that the γ-dose was 10 per cent of the β-dose, the total (β + γ) dose was $0{\cdot}09_5$ rad. A similar calculation for subject *B* gave a total (β + γ) dose to thyroid tissue of $0{\cdot}09_1$ rad.

Table 3. Comparison between measured uptake of Iodine-131 in the Thyroid of Subject *A*, and calculated uptake, assuming an average intake of 1·2 pints Milk daily from a Leeds multiple Dairy (*MA*), an Iodine-131 uptake of 44 per cent in the Thyroid and an effective half-life for Iodine-131 in the Thyroid of 7 days

Date	Observed uptake (in units of 10^{-9} c. iodine-131)	Calculated uptake (in units of 10^{-9} c. iodine-131)	Date	Observed uptake (in units of 10^{-9} c. iodine-131)	Calculated uptake (in units of 10^{-9} c. iodine-131)
Oct. 15	4·1		Oct. 30	8·7	9·4
16	5·2	5·2 assumed	31	8·2	
			Nov. 1	8·8	
17	11	8·2	2		6·8 assumed
18	8·4	9·8			
19	8·6	10·9	3	5·8	6·3
20		13·4	4	5·8	5·8
21	14	12·9	5	5·5	5·4
22	11	12·5	6	5·3	5·0
23	11	11·9	7	4·4	4·6
24	10	11·6	8	3·9	4·2
25	11	11·1	9	3·9	4·0
26		11·0 assumed	10		
			11	3·0	
27		11·5	12	4·0	
28	9·8	10·8	13	3·1	
29	9·8	10·1	14	3·3	

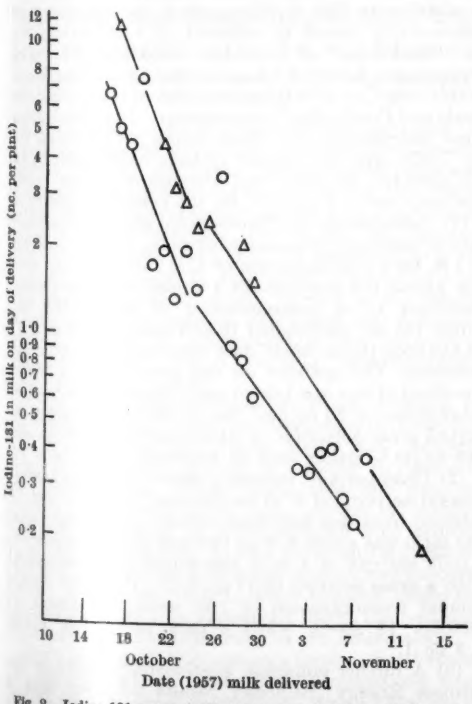

Fig. 2. Iodine-131 concentration (nc. per pint) in milk from a Leeds multiple dairy (*MA*) (○) and from a farm at Farsley (*ME*) (△) versus the date of delivery of the milk

These doses are about the same as the soft-tissue dose received in one year from natural sources of radiation[4] (predominantly local γ-rays, potassium in tissue and cosmic rays). Thyroid doses for adult Leeds residents drinking about one pint of milk daily from the Farsley farm would have been about 0·2 rad and adult Skipton residents would have received some 0·3–0·5 rad. Since the uptake of iodine-131 in the thyroid of subject *N* (4-year-old Leeds boy drinking milk from one of the Leeds multiple dairies) is about the same as for adults drinking similar quantities of the same milk, the dose to his thyroid tissue will be higher (by about four times), in inverse ratio to the thyroid masses.

I am a member of the External Scientific Staff of the Medical Research Council, and am indebted to Mr. D. B. Appleby for extensive assistance with these observations.

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Increase in Background Gamma-Radiation and its Correlation with Iodine-131 in milk

By Prof. F. W. Spiers

Measurements of the γ-ray dose-rate over a lawn and in a house in Leeds had been made during August and September 1957 and it was possible to repeat the measurements on October 19, 1957, and to continue them for some months thereafter. Small, but significant, increases in dose-rate above the summer values were observed in October and it is interesting to consider their relation to the iodine-131 activity in Leeds milk reported in the previous communication.

The measurements were made with a portable high-pressure ionization chamber having long-term stability of response. The chamber, which has a steel wall 0·12 in. thick, operates with a gas filling of 50

atm. of nitrogen, and the change of potential of the central electrode is measured by applying a balancing voltage to the grid of a miniature triode in a Townsend balancing circuit. A drift of 1 V. corresponds to a dose of 0·092 μrad of radium γ-radiation and to 0·108 μrad of γ-radiation from iodine-131. A background γ-ray dose-rate of the order of 10 μrad per hour can be measured with a standard error of ± 1·5 per cent in a single observation of 3–4 min. The standard error of the observations reported here (means of 5 or more readings) is about ± 0·5 per cent.

The stability of response of the instrument is indicated by calibrations carried out with a standard radium source at a dose-rate of approximately 12 μrad/hr., which is of the same order as that from local γ-radiation. The '4π' calibration thus obtained in a large hall, under conditions of minimum scatter, was 0·092 μrad/V. in July 1957, and 0·093 and 0·094 μrad/V., respectively, in April and May 1958. The instrument response to radiation (mainly cosmic) in the Leeds steel room (see previous communication) was 0·465, 0·496, 0·517 and 0·493 V./min. on dates in July, October 1957 and March, May 1958, respectively. The radiation-level in the steel room is unaffected by adventitious changes in the local γ-ray intensity outside it; but the cosmic-ray ionization under the 9-in. steel shielding shows a variation with barometric pressure of − 3 per cent per cm. mercury. Apart from this effect, the response of the instrument in the steel room reflects the stability of the grid current of the electrometer valve which, at $1·9 \times 10^{-15}$ amp., is equivalent to 2 per cent of the current obtained for a typical background γ-ray level. Tests showed that leakage across insulators was insufficient to cause a significant error in the instrument response.

Measurements made at intervals from August 1957 onwards are shown in Fig. 3 for a point 1 ft. above a small lawn, surrounded on three sides by garden but relatively close to the building line, and also for a point in the centre of a ground floor room facing the garden. The results show that, on October 19, 1957, the instrument response over the lawn was 0·23 V./min. above the summer value of 1·75 V./min., corresponding to an increase in γ-ray dose-rate of 1·36 μrad/hr. or about 12 mrad/year. The increase in dose-rate indoors was rather less than half this amount. After falling from the high values of October 19, the γ-ray dose-rates over the lawn and in the house then showed a more or less continued rise which levelled off in the spring of 1958; the relation of these later observations to possible bomb fall-out is the subject of a separate investigation. There can be little doubt that the sharp rise and fall of dose-rate shown in October 1957 was caused by deposition from the Windscale cloud. It is known from Chamberlain[1] that the escape of radioactivity from the reactor was mainly iodine-131 with at first a considerable fraction of the 3·2 day isotope tellurium-132 and its decay product iodine-132; small percentages of other γ-ray emitters, cæsium-137, rubidium-103 and zirconium-95 – niobium-95, were also present. It can thus be estimated that, of the total increase in γ-ray dose-rate of 1·36 μrad/hr. on October 19, 0·6 μrad/hr. was attributable to the isotope iodine-131.

The relationship between the observed γ-ray dose-rates and the milk activity in Leeds can be compared with deductions from observations of the higher dose-rates and milk activities made in Cumberland by the

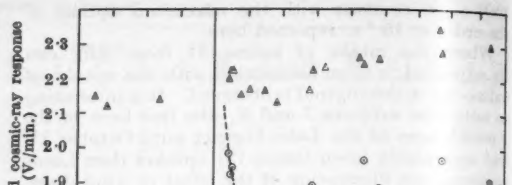

Fig. 3. Total response of a high-pressure ionization chamber to cosmic radiation, local γ-radiation and γ-radiation from adventitious radioactivity. △ over a lawn; ⊙ in a house. The dotted curve indicates the expected decay of the response for the iodine-131, tellurium-132, iodine-132 and other isotopes in the Windscale deposit

Atomic Energy Authority. In order to compare directly with the Cumberland observations, however, some allowance must be made for the fact that the Leeds measurements were in a built-up area where the ionization chamber was screened from a considerable fraction of the radiation it would have received in open country. Chamberlain[1] has shown that the dose-rate at 1 m. above a circular area of radius 10 m. contaminated with iodine-131 is only 40 per cent of that from an infinite plane. It can be deduced that at the Leeds site, at about 3 m. from the building line, the observed dose-rate would be some 60 per cent of that for similarly contaminated open country. In addition to this shielding effect, the deposition of radioactivity would be affected to some extent by the 'shadowing' of near-by buildings. A very approximate factor of 2 has therefore been introduced at this stage, as an adjustment, before comparing the Leeds and Cumberland observations. In the following three comparisons the 'open country' dose-rates for the Leeds area on October 19 have been taken to be 2·7 μrad/hr. for the total increment in the γ-ray dose-rate and 1·2 μrad/hr. for the iodine-131 fraction.

(1) Calculations by Chamberlain[1] give the dose-rate over a uniformly contaminated plane as 7·7 μrad/hr. at 1 ft. for a contamination of 1 μc. iodine-131 per m.^{2}. The iodine-131 dose-rate of 1·2 μrad/hr. corresponds, therefore, to a contamination of about 160 nc. iodine-131/m.^{2} on October 19 and hence to 200 nc./m.^{2} on October 16, on which date other measurements are available. The activity on the grass itself is about one-third of this (see below) and a figure of the implied magnitude, ~ 70 nc./m.^{2}, fits in with the nearest reported grass activities of 81 nc./m.^{2} at Sheffield and 169 nc./m.^{2} farther west at Burnley[2] on October 16.

(2) Chamberlain[1] reports a ratio of grass activity/ground activity of 0·16 on October 28 and it can be inferred from this and other results in his paper that the ratio was about 0·3 on October 19. Furthermore, a milk activity of 1 μc./l. was found to be associated with a grass activity of 11 μc./m.^{2}. It follows that a ground contamination of 160 nc/m.^{2} in Leeds on October 19 should yield a milk activity of about 4·3 nc./l.

(3) A further empirical relationship evident in the Atomic Energy Authority results indicated that a milk activity of 1 μc./l. was associated with a γ-ray dose-rate of 0·45 mrad./hr. at 1 ft. above open ground.

The increment in the γ-ray dose-rate in Leeds of 2·7 μrad/hr. on October 19 would be associated, on this basis, with a milk activity of 6·0 nc./l. This expected value and that in (2) are in reasonable accord with the iodine-131 contents of Leeds milks which on October 20 ranged from 2·5 to 10·5 nc./l. with a mean of 7 nc./l.

It is evident from these comparisons that, with the introduction of a factor 2 for the shielding in the built-up area, the ratios of the γ-ray dose-rates to the milk activities, measured at trace-levels in Leeds, are in substantial agreement with those observed at levels some hundred times greater in Cumberland.

In addition to comparisons with similar observations by the Atomic Energy Authority, it is of interest to see to what extent the results of the milk and γ-ray measurements fit in with theoretical estimations based on the cow's known grazing habits and its metabolism of iodine. The basic data required[2] are the average area grazed by a cow per day and the iodine-131 level in cow's milk on the days following the ingestion of a known quantity of that isotope[4]. A relationship between the activity on the ground and the fraction retained by the grass must also be known; this can be based on measurements given by Chamberlain[1] for October 28. It is to be expected that this fraction must change with time and there is experimental evidence for this in Fig. 4 of Chamberlain's paper, where the ratio of ground iodine-131 activity to the milk activity increases with time. If, following Chamberlain's data, the ratio of grass to ground activity is assumed to be 0·45 on October 11, and falling to 0·3 on October 18, the ground contamination of 160 nc./m.[2] given above for October 19, together with the biological data, would lead to an expected milk activity of 48 nc./l.—a value some seven times higher than the mean observed in Leeds. Other calculations, on the basis of a grass/ground fraction of 0·16 on October 18 and a half-period of 3 days for iodine-131 on grass (as was observed for Leeds milk), lead to lower values for the milk activity, but such assumptions would seem to be less plausible.

Neither the Leeds observations, nor, by inference, those of the Atomic Energy Authority, would seem to fit the biological data at all well, but it is scarcely to be expected that any close correlation would be shown when milk is drawn from a wide area and the autumn feeding regime is likely to be very variable. Further experimental investigations of the relation between grass contamination and ground γ-ray dose-rate and its variation with time after deposition would, however, appear to be very worth while.

I am indebted to Mr. D. B. Appleby and to Mr. R. Corry for assistance in the design of the portable high-pressure ionization chamber and for its construction.

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VITAMIN B_{12} AND PROTEIN BIOSYNTHESIS

Vitamin B_{12} and Biosynthesis in Chick Liver

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In recent years evidence has been produced that the steps of incorporation of amino-acids into proteins include: (i) an activation dependent on adenosine triphosphate of the amino-acids through the COOH group, with the formation of an amino-acid–adenosine monophosphate complex by means of enzymes present in the soluble cell-sap; (ii) stabilization of the activated amino-acid by the transfer to a ribonucleic acid of low molecular weight present in the soluble cell-sap; (iii) a transfer dependent on guanosine triphosphate of the amino-acid to the microsomal ribonucleoprotein where peptide bond-formation apparently takes place.

A microsome-rich preparation which contains all the necessary components for these steps of incorporation was prepared by Wagle, Mehta and Johnson[1] from the livers and spleens of vitamin B_{12}-deficient and normal rats. They found that the deficient preparations incorporated less carbon-14 labelled methionine, alanine or phenylalanine into protein. Addition of vitamin B_{12} *in vitro* significantly increased incorporation into both deficient and normal preparations. In a later paper[2], these workers suggested that vitamin B_{12} is associated with the enzymes concerned with the activation of the amino-acids.

The purpose of this communication is to report on observations we made with preparations from normal and deficient chick livers, which have led us to different conclusions.

Experimental methods. All the chicks used in this work were hatched from eggs from hens given an all-vegetable diet deficient in vitamin B_{12} and were maintained for 4 weeks as described by Coates, Harrison and Kon[3]. Typical weights at 4 weeks were: deficient birds, 120 gm.; control birds (receiving vitamin B_{12} 1 μgm./100 gm. diet), 200 gm.

The carbon-14 labelled amino-acids and phosphate (^{32}P) were obtained from the Radiochemical Centre, Amersham. Vitamin B_{12} labelled with cobalt-60 was kindly provided by Dr. E. L. Smith, of Glaxo Laboratories, Ltd.

We are grateful to our colleague, Dr. M. E. Gregory, for the microbiological assays of vitamin B_{12}, which were made with *Lactobacillus leichmannii* (Gregory)[4].

Determinations of cobalt-60 were made in a well-type, activated sodium iodide crystal scintillation counter. Standards were counted at the same time and all results are expressed as micrograms of vitamin B_{12}. All carbon-14 and phosphorus-32 samples were counted in a 'Tracerlab' gas-flow counter. The counts recorded here are presented as counts/min./cm.^{2} at infinite thickness, corrected for background.

The chicks were killed by breaking the neck. Livers were quickly excised and plunged into ice-cold 0·25 *M* sucrose, or medium *A*[5]. After cooling for a few minutes, they were dried rapidly on filter paper and minced with an ice-cold metal mincer. The mince was then suspended in 2·3 volumes of medium *A*, or 3·0 volumes of 0·25 *M* sucrose, buffered or unbuffered according to the particular needs of the experiment. The suspensions were homogenized in a Potter–Elvehjem homogenizer having a loose-fitting

Table 1. Distribution of Cobalt-60-B_{12} in Chick Livers

Cell fraction	mμgm. Cobalt-60 vitamin B_{12}	Percentage of total
Debris	11·6	58·8
Mitochondria	0·75	3·8
Microsomes	0·93	4·7
Supernatant	6·5	32·8
(i) pH 5 enzyme	1·2	5·9
(ii) pH 5 supernatant	5·3	26·9

nylon pestle, six passes at approximately 1,000 rev./min. being made within 20 sec. The cell fractions were then separated by differential centrifugation for 10 min. at 700*g*, to sediment debris and nuclei, for 10 min. at 7,000*g* for mitochondria and for 1 hr. at 105,000*g* to sediment microsomes. The *p*H 5 enzymes were prepared essentially as described by Hoagland, Keller and Zamecnik[6], washed once with approximately 10 volumes of ice-cold 0·15 potassium chloride and the precipitated *p*H 5 enzymes redissolved in a volume of the appropriate medium equivalent to the weight of tissue used in the preparation. Under these conditions the concentrations of protein (10–15 mgm./ml.) and of soluble cell-sap nucleic acid (2·5–3 per cent of the protein) from both B_{12}-deficient and normal chick livers were the same. The concentration of soluble cell-sap nucleic acid was determined by the method of Hoagland, Stephenson, Scott, Hecht and Zamecnik[7].

The protein samples for counting were isolated by precipitation with 10 per cent trichloracetic acid containing 1 per cent of appropriate carrier. The precipitates were afterwards put through the twelve-stage procedure described by Simkin and Work[8]. The total *p*H 5 fraction, consisting of *p*H 5 protein with soluble cell-sap nucleic acid, was precipitated in ice-cold 5 per cent trichloracetic acid containing 1 per cent carrier, washed twice with ice-cold 5 per cent trichloracetic acid, then with 95 per cent ethanol, acetone, ethanol/ether (3 : 1) and finally ether.

Vitamin B_{12} in Chick Livers and its Distribution in the Cells

The vitamin B_{12} content of the deficient chick livers used in these experiments ranged from 0·012 to 0·017 μgm./gm. fresh liver, whereas those of control birds contained 0·077–0·090 μgm./gm. Only a small proportion (approximately 10 per cent) of the vitamin was found in the *p*H 5 enzymes isolated from these livers; for example, the *p*H 5 enzymes from 1 gm. fresh deficient liver contained 0·8 mμgm. vitamin B_{12} and those from 1 gm. normal liver, 7·0 mμgm. vitamin B_{12}. To study the distribution of vitamin B_{12}, three deficient chicks, average weight 120 gm., were given two intramuscular injections of 1 μgm. cobalt-60 vitamin B_{12} (= 0·24 μc.), one 48 hr. and the other 24 hr. before removal of the livers. The livers were pooled, minced and cell fractions prepared. The distribution of cobalt-60 radioactivity, which is assumed to be vitamin B_{12}, is shown in Table 1. The deficient livers, which would probably contain approximately 15 *mμgm./gm. of 'natural' vitamin* B_{12}, took up another 20 mμgm./gm. of the vitamin; but, contrary to the findings of Wagle *et al.*[3], the *p*H 5 enzymes contained only a small proportion, 5·9 per cent, of this additional vitamin B_{12}. The largest amount of the vitamin was found in the cell supernatant fraction. Very similar results were obtained by incubation of 3 gm. deficient liver mince from similar birds with 2 μgm. cobalt-60 vitamin B_{12} *in vitro*. Therefore, there seems no reason for describing the *p*H 5 enzymes as the "vitamin B_{12} enzyme"[1].

In vitro Incorporation of Amino-acids in Chick Liver

(i) *Mince experiments.* Immediately after mincing, 3-gm. portions of deficient or normal livers and 9 ml. ice-cold Krebs–Ringer bicarbonate–glucose buffer[9] were put into Krebs pots. The buffer contained 0·25 *M* sucrose and 2 μc. carbon-14 *Chlorella* hydrolysate (specific activity 60 μc./mgm.). The samples were incubated at 38° C. in a Warburg bath with gentle shaking and continuous gassing with oxygen + 5 per cent carbon dioxide. After appropriate intervals the flasks were removed and kept in an ice-bath. The mince suspensions were homogenized in their medium, cell fractions separated and counted.

In all, four mince experiments were carried out. In two there was a slight effect of addition of vitamin B_{12} to deficient livers and in the other two no effect. The results are shown in Table 2. In Table 2*A* it is shown that the deficient livers incorporated less carbon-14 amino-acids into cell debris, mitochondria and supernatant proteins, although there was no difference in incorporation into microsomes, which is taken to be the first site of peptide bond formation. In these two experiments with deficient livers when vitamin B_{12} had an effect, the incorporation increased up to the level of that in control livers without affecting incorporation into microsomes. The other type of situation encountered is shown in Table 2*B*. Here the deficient livers incorporated less amino-acids into cell fractions, including microsomes, but addition of vitamin B_{12} had no effect on the incorporation.

Table 2. Incorporation of Amino-acids into Chick Liver Mince
2 μc. Carbon-14-*Chlorella* amino-acids per 3 gm. mince and 9 ml. Krebs–Ringer–sucrose. Incubation in oxygen plus 5 per cent carbon dioxide at 38° C.

Proteins of cell fraction	Time (min.)	Counts/min./cm.² Normal	Deficient	Deficient + 2 μgm. vitamin B_{12}
		(*A*)		
Debris	0	8	4	4
	20	67	53	61
	40	91	55	88
Mitochondria	0	0	0	9
	20	82	49	57
	40	103	66	91
Microsomes	0	0	0	0
	20	92	96	130
	40	132	139	137
Supernatant	0	8	7	7
	20	35	36	38
	40	50	44	63
		(*B*)		
Debris + mitochondria	0	11	13	10
	5	22	18	14
	20	45	37	38
	40	108	35	35
	120	158	76	67
Microsomes	0	6	8	4
	5	24	22	18
	20	77	86	86
	40	146	82	78
	120	147	95	81
Supernatant	0	29	41	30
	5	35	35	46
	20	45	55	52
	40	88	47	49
	120	126	49	55

In view of the variable results obtained with the minces, we examined microsome-rich and *p*H 5 enzyme systems.

(ii) *Microsome-rich fractions.* The microsome plus supernatant fraction, prepared from a homogenate of liver mince with 3 vol. of 0·25 *M* sucrose, was incubated together with the carbon-14 amino-acid (final concentration usually 0·5 μc./ml.), magnesium ions, adenosine triphosphate buffer at *p*H 7·4, and with potassium 3-phosphoglycerate as described by Simkin and Work[10]. Incubation was at 38° with vigorous gassing with either nitrogen + 5 per cent carbon dioxide (anaerobic) or oxygen + 5 per cent carbon dioxide (aerobic), and samples were taken at 0, 20 and 40 min. for precipitation with 10 per cent trichloracetic acid containing 1 per cent carrier to give microsome-rich protein fraction or for dilution with ice-cold 0·25 *M* sucrose, containing 0·005 *M* carrier amino-acid, from which the microsomes were separated by centrifugation.

With carboxyl-labelled DL-alanine the effect of graded amounts of cyano- or hydroxo-cobalamin on incorporation into microsome-rich protein was studied and the results are shown in Table 3. With this amino-acid, in two experiments, we obtained greater incorporation into the deficient preparations, and *in vitro* addition of *both* forms of the vitamin slightly increased incorporation into deficient preparations.

The generally labelled amino-acids of *Chlorella* hydrolysate were incorporated to the same extent into the microsome-rich protein of deficient and normal chick livers (Table 4). Vitamin B_{12} added *in vitro* to deficient preparations was without effect (two experiments) and there was no difference in incorporation in aerobiosis or anaerobiosis. Table 5 shows the incorporation of carbon-14 L-leucine into microsomal proteins, and in this instance there was less incorporation into deficient preparations; but again vitamin B_{12} had no effect on the amount of incorporation. The anilide of the monocarboxylic acid prepared from vitamin B_{12}[11,12], which has a growth inhibition index for *E. coli* 113/3 of 2,000, had a very slight depressing effect on incorporation when used at a high concentration of 280 μgm./ml. Dr. M. E. Coates (personal communication) has found that this substance antagonizes the growth of chicks. Chloramphenicol at a bactericidal concentration (200 μgm./ml.) did not inhibit incorporation. This phenomenon has been noted by other workers in mammalian systems (for example, rat liver and guinea pig mammary gland, Fraser, M. J., Shimizu, H., and Gutfreund, H. G., unpublished work) and suggests that the reported incorporations are not due to bacterial contamination. In further experiments with leucine, vitamin B_{12} and the anilide did not alter the amount of amino-acid taken up; but in these experiments there was no difference between normal and deficient preparations.

Table 3. INCORPORATION OF ALANINE INTO MICROSOME-RICH FRACTION OF CHICK LIVER. EFFECT OF GRADED DOSES OF VITAMIN B_{12}

0·5 μc. Carbon-14 DL-alanine per ml. final medium (see text); time of incubation 20 min. Incubation in nitrogen plus 5 per cent carbon dioxide at 38° C.

	Counts/min./cm.² total microsome-rich protein	
	Normal chicks	*Deficient chicks*
Cyanocobalamin (mμgm./ml.)		
Blank (zero time)	0	7
0	50	57
25	40	67
100	40	73
500	43	70
Hydroxocobalamin (mμgm./ml.)		
Blank (zero time)	0	2
0	50	57
50	47	70
250	47	76

Table 4. INCORPORATION OF AMINO-ACIDS INTO MICROSOME-RICH FRACTION OF CHICK LIVER

0·93 μc. Carbon-14-*Chlorella* amino-acids per ml. final medium (see text). Incubation in either oxygen plus 5 per cent carbon dioxide (aerobic) or nitrogen plus 5 per cent carbon dioxide (anaerobic) at 38°C.

Time (min.)	Counts/min./cm.² total microsome-rich protein					
	Aerobic			Anaerobic		
	Normal	Deficient	Deficient + 2 μgm. vitamin B_{12}/3 ml.	Normal	Deficient	Deficient + 2 μgm. vitamin B_{12}/3 ml.
0	50	62	60	50	55	55
20	174	162	169	153	156	159
40	206	211	221	204	230	210

Table 5. INCORPORATION OF LEUCINE INTO MICROSOME-RICH FRACTION OF CHICK LIVER. EFFECT OF VITAMIN B_{12} AND ANTI-VITAMIN B_{12} AND CHLORAMPHENICOL

0·55 μc. Carbon-14 generally labelled L-leucine per ml., final medium (see text). Incubation in nitrogen plus 5 per cent carbon dioxide at 38° C. Vitamin B_{12} and its peptide complex added at 280 mμgm./ml. and the anilide of vitamin B_{12} 280,000 mμgm./ml. Chloramphenicol was added at 200 μgm./ml. medium

Time (min.)	Counts/min./cm.² microsomal protein						
	Normal	Normal + vitamin B_{12}	Normal + anti-vitamin B_{12}	Normal + chloramphenicol	Deficient	Deficient + vitamin B_{12}	Deficient + vitamin B_{12} peptide
0	30	27	33	47	50	43	43
20	177	170	140	190	100	104	93
40	220	224	183	233	110	110	100

Amino-acid Activation

(i) *Hydroxamate test.* The particle-free supernatant fraction was used to follow the rate of formation of amino-acid hydroxamate essentially as described by Hoagland, Keller and Zamecnik[6]. The incubation mixture contained 5 ml. 2 *M* salt-free hydroxylamine, 1 ml. 0·01 *M* magnesium potassium adenosine triphosphate (MgK_2ATP), 2 ml. complete amino-acid mixture giving in the medium a 0·02-*M* concentration of each amino-acid, 1 ml. 1 *M tris* buffer *p*H 7·6 and 1 ml. cell-supernatant proteins. The blank control contained everything except the amino-acid mixture, and the substantial colour obtained in it was due to formation of hydroxamate by endogenous amino-acids and other compounds in the supernatant fraction.

Three experiments on the formation of hydroxamate were carried out and the results of one are shown in Fig. 1. In all experiments the deficient supernatant fraction had a rate of formation of hydroxamate, that is, of amino-acid activation, nearly twice that of the normal preparation, and it was not changed by *in vitro* addition of vitamin B_{12}.

(ii) *Pyrophosphate exchange.* A dilution of the *p*H 5 enzyme 1 : 10 with *tris* buffer *p*H 7·6 was used to measure the adenosine triphosphate–phosphate (^{32}P) exchange. The final incubation mixture contained 0·002 *M* adenosine triphosphate, 0·002 *M* phosphate (^{32}P), 0·01 *M* magnesium chloride, 0·5 mgm./ml. of *p*H 5 enzyme, 0·1 *M tris* buffer *p*H 7·6 and a single amino-acid, 0·001 *M*, either alanine, leucine or tryptophan. After incubation at 37° C. for various lengths of time, 3-ml. samples were taken into

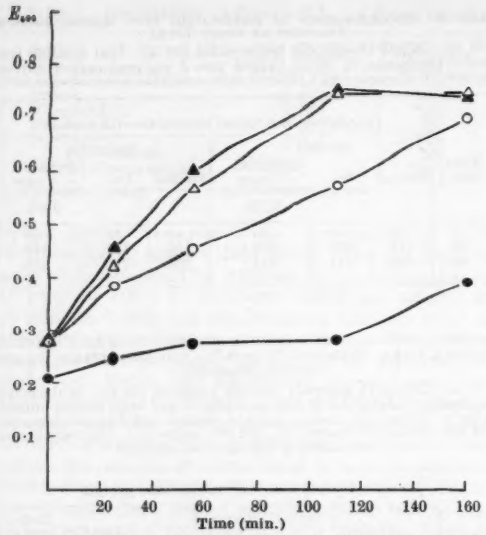

Fig. 1. Formation of hydroxamate in chick liver supernatant fractions

Hydroxamate formed after incubation of cell supernatant with a complete mixture of amino-acids. △, Deficient-liver supernatant; ▲, deficient-liver supernatant + 200 μgm. B_{12}/ml.; ○, normal liver supernatant; ●, blank, that is, without amino-acid mixture

7 ml. 10 per cent trichloracetic acid. The precipitated protein was removed and the adenosine triphosphate (^{32}P) was adsorbed on 100 mgm. activated charcoal as described by Crane and Lipmann[13] and counted.

In duplicate experiments using alanine and leucine, there was no significant difference between deficient and normal *p*H 5 enzymes, in the amount of phosphate (^{32}P) exchange. Vitamin B_{12} added to the deficient enzyme had no effect on the system, as can be seen in Table 6. However, addition of 2 mgm. of the anilide of vitamin B_{12} to the normal enzyme did depress the amount of exchange, in confirmation of the report of Wagle *et al.*[2]. Vitamin B_{12} even at high concentration only partially reversed this inhibition. Omission of the amino-acid from the incubation mixture had little effect on the exchange. Since the amount of endogenous amino-acid left on the washed and diluted *p*H 5 enzyme was probably very small, the pyrophosphate exchange may not have been measuring amino-acid activation. That the reaction was enzymic is shown by its inhibition by 10^{-4} *M* *p*-chloromercuribenzoate.

(iii) *Incorporation of carbon-14 amino-acids into* p*H* 5 *enzymes.* The *p*H 5 enzymes were dissolved in a buffered medium similar to that described by Keller and Zamecnik[5] containing 0·35 *M* sucrose, 0·035 *M* potassium bicarbonate, 0·025 *M* potassium chloride, 0·01 *M* magnesium potassium adenosine triphosphate, and 0·5 μc./ml. carbon-14 amino-acid. Incubation was at 37° C. for various times. The total labelled *p*H 5 fraction (that is, soluble cell-sap nucleic acid + protein) and also the labelled *p*H 5 protein were isolated. Three experiments with carbon-14 generally labelled L-leucine and one experiment with carbon-14 *Chlorella* hydrolysate gave very similar results. Fig. 2 shows results with leucine. In all experiments the deficient *p*H 5 enzyme, in spite of its lower vitamin B_{12} content, became labelled faster than the normal *p*H enzymes, the rate in some experiments being at least double. The effect was tried of a number of substances on the rate of incorporation. Neither the anilide derivative of vitamin B_{12} nor

Table 6. Pyrophosphate Exchange into Adenosine Triphosphate using *p*H 5 Enzymes from Normal and Deficient Chick Liver

Final medium contained: L-leucine, 0·001 *M*; MgK_2ATP, 0·002 *M*; $P^{32}P$, 0·002 *M*; Mg^{++}, 0·01 *M*; *tris* buffer, 0·1 *M* *p*H 7·6 and *p*H 5 enzyme

*p*H 5 enzymes gave final protein concentration 0·35 mgm./ml. normal and 0·39 mgm./ml. deficient. The concentration of soluble cell-sap nucleic acid was 0·010 mgm./ml. for normal and 0·011 mgm./ml. for deficient

Vitamin B_{12} added at 200 mμgm./ml. and the anilide of vitamin B_{12} at 200,000 mμgm./ml.

Blank obtained by adding 10^{-4} *M* *p*-chlormercuribenzoate

Time (min.)	Adenosine triphosphate-^{32}P adsorbed on charcoal (counts/min./mgm. charcoal)				
	Blank 10^{-4} *M* *p*-chlormercuribenzoate	Normal	Normal + anti-vitamin B_{12}	Deficient	Deficient + vitamin B_{12}
0	0·22	0·33	0·44	0·43	0·25
15	0·56	10·2	6·68	11·2	10·5
30	0·50	20·1	12·7	22·5	22·6

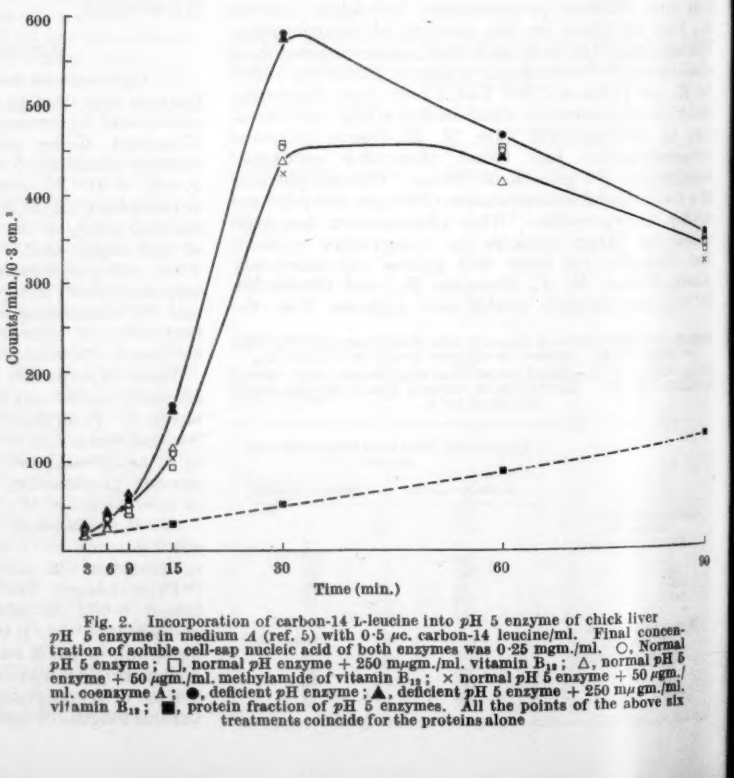

Fig. 2. Incorporation of carbon-14 L-leucine into *p*H 5 enzyme of chick liver

*p*H 5 enzyme in medium *A* (ref. 5) with 0·5 μc. carbon-14 leucine/ml. Final concentration of soluble cell-sap nucleic acid of both enzymes was 0·25 mgm./ml. ○, Normal *p*H 5 enzyme; □, normal *p*H enzyme + 250 mμgm./ml. vitamin B_{12}; △, normal *p*H 5 enzyme + 50 μgm./ml. methylamide of vitamin B_{12}; × normal *p*H 5 enzyme + 50 μgm./ml. coenzyme A; ●, deficient *p*H enzyme; ▲, deficient *p*H 5 enzyme + 250 mμgm./ml. vitamin B_{12}; ■, protein fraction of *p*H 5 enzymes. All the points of the above six treatments coincide for the proteins alone

the corresponding methyl amide had any effect on the normal enzymes, and vitamin B_{12} itself did not affect deficient or normal preparations. Vitamin B_{12} deficiency often leads to an elevated level of coenzyme A in liver[14], which it was thought could account for the increased incorporation in deficient liver, since Airth, Rhodes and McElroy[15] have shown that coenzyme A can activate certain amino-acids via the carboxyl group in a manner analogous to acetate activation. However, it can be seen that coenzyme A did not increase the rate of incorporation of the normal *p*H 5 enzyme fraction. The proteins present in the *p*H 5 enzyme became labelled linearly to a final 26 per cent of the total carbon-14 in the soluble cell-sap nucleic acid plus protein fraction. Fig. 2 shows that both enzymes and the various treatments lead to the same amount of labelling in these proteins.

Discussion

For our study of the distribution of vitamin B_{12} in liver, we preferred to use deficient chicks, that is, chicks with depleted vitamin B_{12} stores, and inject a dose of cobalt-60 vitamin B_{12} smaller than that used by Wagle *et al.* for normal rats. A further difference was that our dose was given in two portions 48 hr. and 24 hr. before the liver was excised, allowing a greater chance for equilibrium to be established. In this way we found that most of the vitamin was in the *p*H 5 cell supernatant, and hence there was no reason for associating vitamin B_{12} with either the particulate fractions or more especially with the *p*H 5 precipitate that contains the amino-acid activating enzymes. This observation was further confirmed by the finding by direct microbiological assay that only 10 per cent of the total natural vitamin B_{12} content of both deficient and normal livers was present in the *p*H 5 fraction. Even though the *p*H 5 fraction from deficient liver contained only one-tenth of the vitamin B_{12} present in the normal *p*H 5 fraction, the rate of amino-acid activation measured by the hydroxamate test or by incorporation of labelled amino-acid into soluble cell-sap nucleic acid was twice as great as for the normal preparations. The total protein and nucleic acid concentration of the 'deficient' and 'normal' *p*H 5 enzymes were the same. Although the rate of activation appeared greater in deficient livers, the incorporation into microsomal protein was generally the same or lower than into the normal liver fractions. With the adenosine triphosphate – phosphate (^{32}P) exchange as a measure of amino-acid activation, the results are more difficult to interpret, since we did not demonstrate a requirement for amino-acid in our system. Whatever process this exchange is measuring, there was no difference between the normal and deficient *p*H 5 enzymes, and vitamin B_{12} did not affect the exchange. However, the exchange was 35 per cent inhibited by a high concentration of the anilide of vitamin B_{12}, in confirmation of the observation of Wagle *et al.*[2].

Using the more complex fractions rich in microsomes to measure all the steps concerned in the incorporation of amino-acids into protein, we observed in two out of six experiments that the deficient preparations incorporated less carbon-14 amino-acids than the normal. In only one experiment of the six with fractions rich in microsomes was there any indication of an effect of added vitamin B_{12}. Vitamin B_{12} was tested as its cyano-, hydroxo-, and peptide form, and was usually without effect on the incorporation of carbon-14 activity into protein. These results agree with those of Arnstein and Simkin (see following communication), who used vitamin B_{12}-deficient and normal rat-liver preparations rich in microsomes. The anilide of vitamin B_{12} was used at high concentration in two experiments, but there was no depression of incorporation.

Experiments with chick liver minces showed that incorporation of carbon-14 labelled amino-acids into these whole-cell preparations was always less in the minces of vitamin B_{12}-deficient liver. It appeared that a small and erratic effect was obtained in some experiments on the *in vitro* addition of vitamin B_{12}. In similar experiments in which carbon-14 amino-acids were given intravenously into live vitamin B_{12}-deficient chicks and also into deficient chicks that had been given large doses of vitamin B_{12} on two successive days before the experiment, we could find no difference in incorporation into liver or heart muscle proteins. These *in vitro* experiments varied in time from 30 min. to 5 hr. (Coates, M. E., and Holdsworth, E. S., unpublished work).

Since we have not been able to find a direct role of vitamin B_{12} in the activation of amino-acid or in the incorporation into fractions rich in microsomes, it seems probable that the differences in levels of incorporation occasionally observed between deficient and normal microsome-rich preparations, and usually observed in the mince preparations, may reflect an indirect role of vitamin B_{12}.

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Vitamin B_{12} and Biosynthesis in Rat Liver

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THE nutritional importance of vitamin B_{12} for a wide variety of organisms, including mammals, birds, and micro-organisms, is well established. The underlying biochemical functions of the vitamin are, however, still unknown, although several different mechanisms have been suggested (for a recent review see ref. 1). An attractive suggestion, which could explain the diversity of the observed metabolic disturbances in deficient organisms, is the direct participation of vitamin B_{12} in protein biosynthesis and hence in enzyme formation[2,3]. The experimental basis for such a function is the decreased incorporation of labelled serine and glucose into the liver protein of vitamin B_{12}-deficient pigs and rats compared with that found in control animals *in vivo*[2],

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Table 1. Vitamin B_{12} Content of Livers and Growth of Deficient and Control Rats

Exp. No.	Litter and rat No.	Sex	Age (days)	Age when started on oral cyanocobalamin* (days)	Body-weight (gm.)	Vitamin B_{12} content of liver (mμgm./gm. fresh wt.)
1	*AL72/2*	*F*	91	—	143	32
2	*AL72/1*	*F*	75	30	136	200
3	*AL76/3*	*F*	80	—	148	40
4	*AL76/5*	*F*	80	67	160	100
5	*AL78/2*	*M*	63	—	98	16
	AL78/3	*M*	63	—	86	20
	AL78/4	*F*	63	—	92	44
	AL79/4	*F*	63	—	106	30
	AL79/2	*M*	63	32	174	120
	AL79/1	*F*	63	32	152	195
6	*AL78/5*	*M*	71	—	122	25
	AL79/3	*M*	71	—	107	13
	AL80/4	*F*	71	—	70	7
	AL78/1	*M*	71	32	170	160
	AL80/1	*M*	71	31	151	172
	AL80/2	*F*	71	31	120	185

*A dash signifies no cyanocobalamin given

and the reduced labelling of microsome protein of both liver and spleen in a cell-free system[3]. Moreover, the addition of vitamin B_{12} *in vitro* to such a cell-free system from deficient rats has been reported to stimulate the incorporation of labelled methionine, alanine or phenylalanine into protein and thus to be effective in partially restoring protein synthesis to normal levels[3]. This effect of vitamin B_{12} has been ascribed to a function in the carboxyl-activation of amino-acids[4].

Other experimental evidence, however, appears to be in conflict with the foregoing results on the effect of vitamin B_{12} on protein synthesis in the intact rat. Thus, in the rat the incorporation of carbon-14-labelled methionine[5], serine[6], glycine[6] and histidine[7] into protein *in vivo* was not markedly decreased by vitamin B_{12} deficiency. In view of this discrepancy, the present experiments were undertaken in order to investigate further the suggested relationship of vitamin B_{12} to protein synthesis.

Vitamin B_{12}-deficient albino rats were obtained by breeding from depleted mothers which had also been fed on the vitamin B_{12}-deficient diet during pregnancy. The diet[8] had the following composition (gm./100 gm.): soya protein (α-protein, Glidden Co., Chicago, Illinois), 35; lactose, 17; glucose, 30; semi-hardened arachis oil (m.p. 33–35°; British Oil and Cake Mills, Erith), 12; salts (Glaxo mixture No. *DL6*), 5; vitaminized arachis oil[9], 2; and choline chloride, 0·3. Control animals were given vitamin B_{12} (cyanocobalamin) orally soon after weaning in doses equivalent to 5 μgm./rat/day (Table 1). With this diet, differences in body-weight between deficient and control rats usually became quite marked after 4–6 weeks. All livers used in the present experiments were checked for vitamin B_{12} depletion by microbiological assay with *Ochromonas malhamensis* essentially as described by Ford[10]. The average vitamin B_{12} content of deficient livers was 25 mμgm./gm. fresh weight, while livers of control rats contained about 160 mμgm./gm. (Table 1).

Minces were prepared by forcing liver through a metal screen with holes of 1 mm. diameter. Samples (0·5 gm.) from non-fasted deficient and control rats were incubated for 1·5 and 3 hr. under 95 per cent oxygen – 5 per cent carbon dioxide in 10 ml. of bicarbonate medium[11] with or without glucose (10·8 mgm.) and either uniformly labelled L-[^{14}C]valine (0·2 or 0·4 μc.; specific radioactivity, 53 μc./mgm.) or L-[^{14}C]phenylalanine (1 μc.; specific radioactivity, 70 μc./mgm.). After incubation, the flasks were cooled in ice, the medium was decanted and filtered through cotton wool, and the mince was washed twice with 2·5 ml. of 0·56 per cent sodium chloride. An equal volume of 10 per cent trichloracetic acid was added to the combined medium and washings to precipitate the protein (medium protein). The washed mince was suspended in 10 ml. of 0·56 per cent sodium chloride and disintegrated in a Potter-Elvehjem homogenizer with a 'Teflon' pestle. The suspension was centrifuged at approximately 700*g* for 10 min., the sediment was washed with 5 ml. of 0·56 per cent sodium chloride and centrifuged again. The 'soluble cell protein fraction' was precipitated from the original supernatant and washings by adding 10 per cent trichloracetic acid (15 ml.). The 'insoluble cell protein fraction' was obtained by adding 15 ml. of 10 per cent trichloracetic acid to the washed sediment. Each protein fraction was purified by dissolving in *N* sodium hydroxide, adding 10 mgm. of the appropriate unlabelled amino-acid, reprecipitating with 10 per cent trichloracetic acid and removing nucleic acid and lipid as previously described[12].

Table 2 shows that all protein fractions from minces of deficient rats had a lower specific radioactivity than those of controls, the greatest difference being found in the protein of the incubation medium. Addition of vitamin B_{12} *in vitro* increased the radioactivity of the protein only very slightly, however, the increase being usually less than 10 per cent. Since the uptake of vitamin B_{12} by rat liver slices is known to be rapid[13], absence of any marked stimulation of protein synthesis after incubation for 3 hr. would appear to exclude any direct effect of vitamin B_{12} on protein synthesis by intact liver cells.

Cell-free preparations were obtained by homogenizing rat liver in 0·25 *M* sucrose and separating the

Table 2. Protein Biosynthesis by Liver Mince from Vitamin B_{12}-Deficient and Control Rats

All results are calculated on the basis of 1 μc. of carbon-14 amino-acid added per flask. Except for experiment No. 2, results are means of duplicate flasks; individual values differed from the mean by less than 10 per cent in nearly all cases. In experiments Nos. 1 and 2, glucose (10·8 mgm./flask) was added to the medium

Exp. No.	Animal	Radioactive amino-acid added	Cyanocobalamin (10 μgm./flask)	Specific radioactivity of protein (mμc./gm.) after incubation for 1·5 hr. and 3 hr.					
				Protein from medium		'Soluble' cell protein		'Insoluble' cell protein	
				1·5 hr.	3 hr.	1·5 hr.	3 hr.	1·5 hr.	3 hr.
1	Deficient	Valine	–	54	200	435	860	198	352
			+	66	221	414	907	131	337
2	Control	Valine	–	—	665	—	1,139	—	650
			+	—	631	—	1,170	—	650
3	Deficient	Phenylalanine	–	97	350	1,289	2,021	465	854
			+	99	429	1,316	2,275	485	939
4	Control	Phenylalanine	–	159	604	1,685	2,585	664	1,075

microsome – cell sap fraction[14]. Samples of that fraction (2·5 ml.) were incubated at 37° under 95 per cent nitrogen – 5 per cent carbon dioxide with 3-phosphoglycerate as adenosine triphosphate generator and other additions as described elsewhere[15], the total volume being scaled down to 3·6 ml. Each flask contained 2 μc. of L-[^{14}C]phenylalanine (specific radioactivity 70 μc./mgm.). At the end of the incubation period, 2·5 vol. of cold 0·25 *M* sucrose containing unlabelled phenylalanine (1 mgm./ml.) were added and the mixture was centrifuged[15]. Protein was isolated from the microsome and supernatant (cell-sap) fractions[15] and purified as described above.

Fig. 1 shows that the cell-free system from vitamin B_{12}-deficient rats which had been fasted overnight incorporated somewhat less radioactivity into the protein of the microsome and cell-sap fractions than a similar preparation from the control animals. *In vitro* addition of cyanocobalamin (final concentration, 28 mμgm./ml.) had, however, no effect either on the rate of incorporation of phenylalanine into protein or on the final level of labelling. In another experiment with non-fasted rats (Table 3) a higher level of cyanocobalamin (140 mμgm./ml.) was equally ineffective in stimulating incorporation of phenylalanine, either alone or when added together with glutathione ($2·5 \times 10^{-3}$ *M*). Glutathione itself stimulated incorporation (cf. ref. 16), but the effect was relatively small. In a similar experiment with fasted rats which had been fed on a soya flour diet[10] instead of on the α-protein diet, the incorporation of a mixture of labelled amino-acids from hydrolysed [^{14}C]*Chlorella* protein into microsome protein was studied. The growth of deficient rats was retarded, but their livers were not as markedly depleted as those in the experiments in Table 1. Deficient animals had body-weights of 87, 95 and 105 gm. and a mean level of

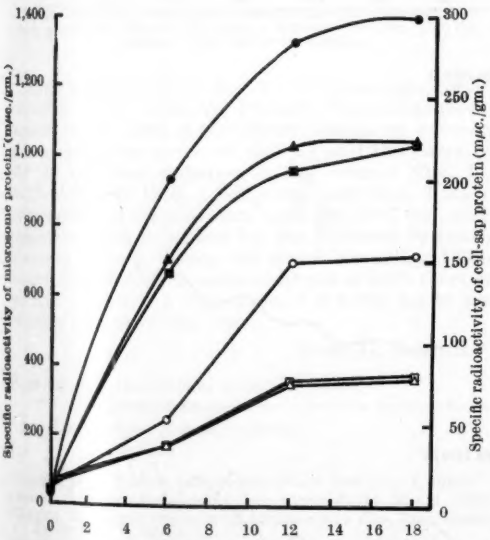

Fig. 1. Incorporation of L-[^{14}C]phenylalanine into protein by cell-free preparations from vitamin B_{12}-deficient and control rats ●, Microsome protein, control group; ▲, microsome protein, deficient group – cyanocobalamin; ■, microsome protein, deficient group + cyanocobalamin; ○, cell-sap protein, control group; △, cell-sap protein, deficient group – cyanocobalamin; □, cell-sap protein, deficient group + cyanocobalamin

Table 3. Effect of Vitamin B_{12} and Glutathione on the Incorporation of L-[^{14}C]Phenylalanine into the Protein of Microsome and Cell-sap Fractions of Liver by a Cell-free System (Experiment No. 6)

Incubation time was 20 min. The animals (see Table 1) were used without previous fasting. Results are mean values of duplicate flasks, except in the case of the non-incubated flasks; individual results differed from the mean by less than 5 per cent

Source of liver	Addition to flasks	Specific radioactivity (mμc./gm.) Microsome protein	Cell-sap protein
Deficient rats	None	1,343	102
	Cyanocobalamin (0·5 μgm.)	1,354	93
	Glutathione (2·4 mgm.)	1,492	125
	Cyanocobalamin (0·5 μgm.) + glutathione (2·4 mgm.)	1,439	109
	None*	29	15
Control rats	None	1,341	99
	None*	20	13

* Flask kept at 0° C.

vitamin B_{12} in the liver of 98 mμgm./gm.; the corresponding values for control rats were 122, 122, 119 gm., and 160 mμgm./gm. Incubation was carried out under either 95 per cent nitrogen – 5 per cent carbon dioxide (for 10 min.) or 95 per cent oxygen – 5 per cent carbon dioxide (for 10 and 20 min.) and cyanocobalamin was added at 100 mμgm./ml. There was no significant difference in the radioactivity of the microsome protein of the preparations from the deficient and control animals. The radioactivity of the protein of the deficient cell-free system was increased by the addition of vitamin B_{12} by less than 15 per cent.

The experiments with liver minces indicate that the incorporation of amino-acids into protein was less in livers of vitamin B_{12}-deficient rats than in those of control animals. Factors such as the size of the free amino-acid pool can, however, influence the rate of incorporation of labelled amino-acids into protein. The greatest difference was found in protein of the medium, which would be compatible with a decrease in protein secretion rather than in protein synthesis in vitamin B_{12} deficiency. There is, however, no indication that addition of the vitamin stimulates incorporation appreciably. Moreover, the experiments with cell-free systems failed to confirm the reported stimulation of protein synthesis by addition of vitamin B_{12} *in vitro*[9].

While our results do not exclude the possibility that vitamin B_{12} deficiency may result in decreased protein synthesis, they suggest that such an effect is secondary to some other biochemical function of the vitamin.

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LETTERS TO THE EDITORS

GEOPHYSICS

Two Atmospheric Effects in the Orbital Acceleration of Artificial Satellites

As I first pointed out[1], the orbital acceleration of artificial Earth satellites shows fluctuations which cannot be explained on gravitational grounds. In satellite 1957 β 1, these oscillations were rather irregular, although cycles of 19 and 37 days could be discerned[2,3]. According to E. C. Cornford[4], a periodicity of about 25 days was indicated, and this gave rise to speculations about possible tidal effects from the Moon. The same hypothesis was tentatively advanced by D. G. King-Hele[5] to explain oscillations with a period of 27 days in satellite 1958 δ 1. Earlier[3], in collaboration with R. E. Briggs, I had found oscillations with a period of about 30 days in satellite 1958 β 2, but had rejected the tidal hypothesis in view of the many observed irregularities and also because lunar tides should result in oscillations with about half the observed period. It was suggested, rather, that the rotation of the Sun, which has a synodic period of 27 days, could be responsible for changes in upper-atmosphere densities through variable radiation.

The oscillations in the orbital acceleration of 1958 δ 1 were quite regular, much more so than in 1957 β 1. Their period, as derived from 5 cycles, was 29 days, and their semi-amplitude was about 10 per cent of the mean acceleration (that is, the amplitude of the waves increased as the acceleration increased with the spiralling in of the satellite). The most remarkable feature of these oscillations, however, was that they were in phase with those of 1958 β 2, as can be seen from Fig. 1. Accurate acceleration data are not available, at present, for satellites 1958 α and 1958 ε, but a qualitative inspection of the available material (Whitney, C. A., private communication) has revealed that their accelerations, too, oscillated in phase with those of 1958 β 2 and 1958 δ 1. Moreover, accelerations obtained by Siry[6] and Whitney[7] for satellite 1958 γ give a maximum at about April 7 and a minimum near April 22, in close agreement with a maximum and a minimum on the curve for 1958 β 2. It appears rather evident that we are dealing with a global effect—a rhythmic pulsation of the atmosphere as a whole. Since the relative amplitude of the oscillations is much greater for the high-orbiting satellite 1958 β 2 than for the other, lower, satellites, it appears that the amplitude of the atmospheric variations increases with height.

It must be admitted that the regularity of the fluctuations in 1958 δ 1 is a little embarrassing for the solar-radiation hypothesis. Also, the period cannot be brought down to 27 days, although a period of 28 days fits the observations well enough (high latitude plages on the Sun could be responsible for a somewhat longer period since the rotation of the sun becomes slower at higher latitudes). A third difficulty consists in the fact that a 27-day periodicity in geomagnetic and ionospheric phenomena often makes its appearance in times of sunspot minima, but generally not in times of maxima—and now we are near a high maximum. In spite of these difficulties, the solar-radiation hypothesis still appears to me, in default of anything better, as the only plausible solution in sight.

Another effect, which is definitely tied to solar radiation, can be detected in satellites 1957 β 1, 1958 β 2, and also in 1958 δ 1. This is a variation of the orbital acceleration with the angular distance ψ of the perigee from the sub-solar point. The acceleration is greater when ψ is smaller, and the relation between the two variables is quite smooth. In particular, there is no discontinuity at the time when the perigee passes from night into daylight or

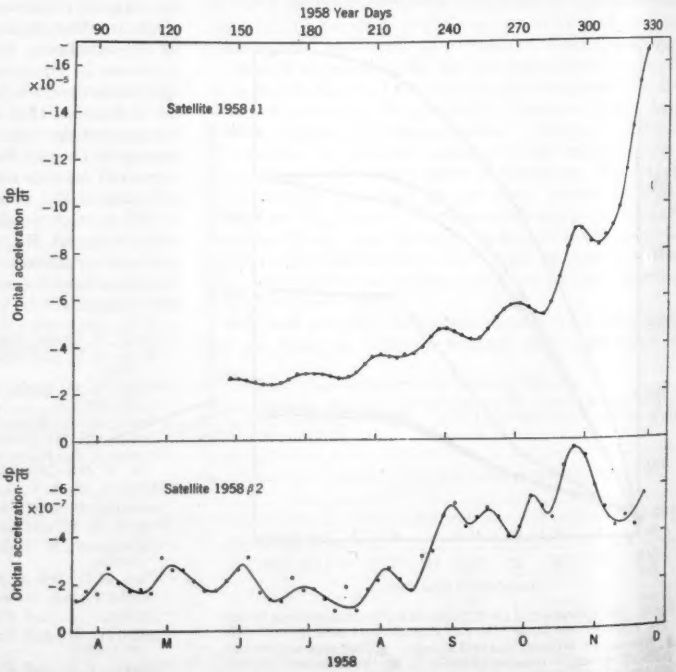

Fig. 1. Comparison of the orbital accelerations of satellites 1958 δ 1 and 1958 β 2 to show the in-phase fluctuations

vice versa, and the relation is quite discernible even in 1958 β 2, for which ψ always varied between 0° and 90° (that is, its perigee was always in the bright hemisphere). There are two possible explanations for this phenomenon. First, it could be due to variable charged drag[3] in an atmosphere in which the ionization decreases with increasing distance from the sub-solar point. In this mechanism the satellite acquires a negative charge which will depend on the degree of ionization of the atmosphere, and there will be a supplementary drag caused by the positive ions it attracts from the sides. The second possibility is a real difference in density of the upper atmosphere between the bright and the dark hemispheres of the Earth. Fig. 2 illustrates the effect for satellite 1957 β 1.

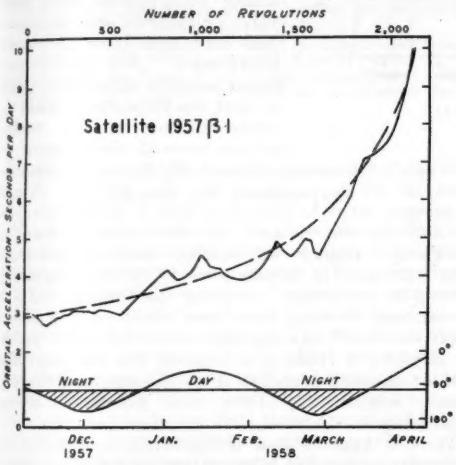

Fig. 2. Orbital accelerations of satellite 1957 β 1 compared with the geocentric angular distance ψ between the Sun and the perigee of the orbit of the satellite

Note added in proof, Jan. 14. In a communication dated Dec. 18, 1958, W. Priester, Universitätssternwarte, Bonn, finds a remarkable similarity between my acceleration curve of 1957 β 1 and the curve of the 20-cm. solar radiation in the interval Nov. 11, 1957–Feb. 10, 1958. Following this hint, I have compared the satellite data with the 10·7-cm. solar radiation data published by the National Research Council, Ottawa, during the period November 1957–December 1958. The correspondence is little short of perfect; there is a suggestion of a 2-day lag in the atmospheric (satellite) curve.

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Irregularities in the Density of the Upper Atmosphere: Results from Satellites

WHEN an Earth satellite encounters air drag its orbit contracts and its period of revolution T decreases. For most of the satellites so far launched the rate of decrease of T has been irregular, thus implying irregularities in drag, which could be caused by changes in either the effective atmospheric density near perigee or the effective cross-sectional area S of the satellite perpendicular to the direction of motion. If, like most of those so far launched, the satellite does not point in a specific direction but rotates, S is to be taken as the mean cross-section during one complete rotation. The mean cross-section should remain constant as long as the mode of rotation of the satellite is unchanged, though it would not be constant if, for example, tumbling end-over-end changed to spinning like an aeroplane propeller. A clue to the mode of rotation is provided by the fluctuation in brightness of a satellite; if this remains almost the same for many months it is unlikely that the mode of rotation has changed appreciably.

For the rocket of *Sputnik* 3 (1958 δ 1), the rate of decrease of period was particularly erratic[1], but the brightness fluctuated regularly with a period which increased slowly from 8·5 sec. in July to 9·5 sec. in November. This strongly suggests that the mean cross-section did not vary significantly and that irregularities in the rate of decrease of period can be ascribed to variations in atmospheric density. Similar conclusions apply[2] to *Sputnik* 2 (1957 β). For both these satellites the perigee height decreased from 226 km. initially to about 180 km. 10 days before the end of the satellite's life, and any conclusions about air density relate to this height band.

The Royal Aircraft Establishment provided a prediction service for *Sputnik* 3 rocket, and more than 600 observations were received. A preliminary analysis of these has now been made, and the rate of change of nodal period has been calculated at intervals of 3 or 4 days. The results are shown in Fig. 1, in which the great majority of the observed values plotted are believed to be in error by less than 0·1 sec./day. For comparison, a theoretical curve, calculated on the assumption that density is constant from day to day, is also shown in Fig. 1. This curve is derived from the simplest theory, which gives:

$$\frac{dT}{dt} = -\frac{3e_0T_0}{4t_L\sqrt{1-t/t_L}}$$

where t is time after launch, t_L is the total lifetime, e_0 the initial eccentricity, and T_0 the initial period. In assessing the irregularities in dT/dt, no advantage is gained by using a subtler theory.

The main feature which stands out in Fig. 1, and even more in Fig. 2, where the observed values have been divided by the theoretical, is an oscillation with a period of about 28 days. This oscillation seems more likely to be linked with solar disturbances than with lunar tides in the atmosphere, because the Moon completed one revolution, relative to the perigee of the satellite's orbit, in about 22 days; whereas the Sun rotates, relative to the Earth, once every 27·3 days. The rather sharp onset of the increases in drag, together with the fact that their periodicity agrees better with the solar period than the lunar one,

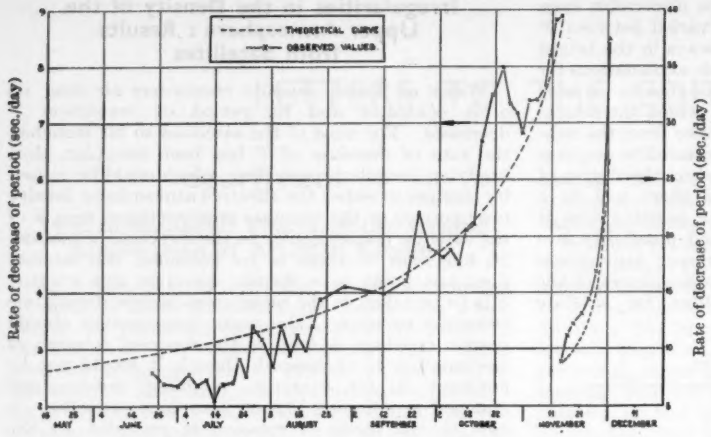

Fig. 1. Rate of change of period for *Sputnik* 3 rocket (1958 δ1)

suggests that the changes in air density are associated with the streams of particles which are projected radially from the Sun and sweep across the Earth at intervals of 27–28 days, giving rise to well-known periodicities in geomagnetic activity[3], cosmic rays and the aurora[4].

Other possible causes of irregularities in air density do not fit in well with the 28-day oscillation. If the movement of perigee from darkness into daylight is an important factor, as suggested by Sedov[5] and Groves[6], there would be an oscillation with a period near 3 months. Figs. 1 and 2 indicate that, though the change in density from day to night may well have some influence, it is not the dominant effect. Another possible source of irregularity is the variation of density with latitude[7]. During the life-time of *Sputnik* 3 rocket, the perigee moved from latitude 50° N. to latitude 20° S. The 28-day periodicity in the values of dT/dt implies maxima of density at intervals of about 10° in latitude. It seems unlikely that the variation of density with latitude should show an oscillatory pattern of this kind, though it cannot be entirely ruled out. It would, however, be surprising to find no variation of density with latitude, and if the irregularities are ignored Fig. 2 might seem to indicate that density increases by about 50 per cent between latitude 40° N. and the equator. The true increase in density is likely to be appreciably less than this, however, since part of the increase is accounted for by the Earth's oblateness, which reduces the height of perigee above the Earth's surface. For the *Sputniks* so far launched, with inclinations near 65°, perigee has taken about a year to make a half-circuit of the Earth, and the increase in the mean value of the quantity plotted in Fig. 2 between latitude 40° N. and the equator can be looked upon as one half-period of the oscillation in dT/dt produced by the periodic change in the latitude of perigee, though some seasonal effect may also be present.

Do the results from other satellites confirm the suggestion that solar disturbances are responsible for the irregularities in air density ? For *Sputnik* 1 and its rocket (1957 α 2 and 1) the data available to us are not precise enough for any conclusions to be drawn. With *Sputnik* 2 (1957 β) a somewhat similar periodicity was discernible[2], with maxima of drag occurring about January 20, February 15 and March 15, 1958 ; and Nonweiler[8] found a significant correlation with solar flares. For *Sputnik* 3 (1958 δ 2), increases in drag occurred about 80, 110 and 140 days after launch, but accurate optical observations have been rather infrequent and the variations have not been accurately determined. For the United States satellite *Explorer* 1 (1958 α), and for *Explorer* 3 (1958 γ), except during its last weeks, perigee crossed the equator at intervals of between 24 and 30 days ; the oscillations in dT/dt produced by the periodic change in perigee latitude therefore had a period between 24 and 30 days[9], and, in the present state of knowledge, cannot be reliably distinguished from solar influences of similar period. With *Vanguard* 1 (1958 β 2) somewhat irregular oscillations with a period near 30 days have been observed and tentatively ascribed[10] to solar influences. Our information on *Explorer* 4 (1958 ε) is limited, but its drag, like that of *Sputnik* 3 rocket (Fig. 2), increased sharply about August 22, 1958, and decreased about September 8.

Thus, it appears that irregularities in air density, especially at heights between 180 and 225 km., tend to recur at intervals of about 28 days, and that this periodicity may well be related to solar disturbances. Variations in density from day to night and with latitude appear to be rather less important. These conclusions must, however, at present be regarded

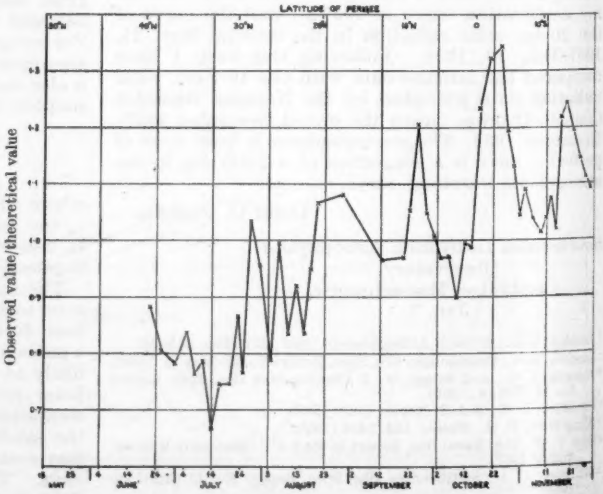

Fig. 2. Rate of change of period of *Sputnik* 3 rocket (1958 δ1). Ratio of observed values to theoretical

as somewhat speculative; there is need for data from further satellites and for a more thorough analysis of existing results.

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Natural Magnetic Moments of Two Chondritic Meteorites

MOST of the secondary or chondritic meteorites are composed of irregular grains of silicate, sulphide, phosphide, oxide and metal phases. They are generally thought to be fragments of secondary meteorite bodies which were themselves accumulations of debris from disrupted primary bodies. The process of compaction of the secondary bodies does not appear to have been accompanied by sufficient heating to have melted any of the constituent phases[1,2], which leads to the general conclusion that these secondary bodies did not have fluid, conducting cores capable of producing terrestrial-type magnetic fields, as is possible in the primary meteorite bodies[3]. This implies that alignment of magnetic particles or induction of thermo-remanent or chemical magnetization is unlikely to have occurred in the secondary bodies and therefore that the chondritic meteorites would not be expected to have magnetic moments other than those acquired on the Earth.

We have found substantial natural magnetic moments in the three chondrites which have been examined and have used two of them (Homestead and Mount Browne) in thermal demagnetization experiments to obtain information about the origin of their moments. The Homestead meteorite is a polymict, brecciated grey bronzite-chondrite[4], and a preliminary modal analysis indicates the magnetic constituents to be 1 per cent magnetite and 9 per cent metal by weight. The Mount Browne chondrite is very similar but with a higher proportion of metal, 19–34 per cent[5]. Samples of about 35 gm. were taken from parts of each of these meteorites, more than 3 cm. below the fused crusts, so that the samples could not have been heated above about 100° C. during ablation in the Earth's atmosphere[6]. Both meteorites were observed falls and no obvious oxidation of the metal phases has occurred in the samples examined.

The magnetic moments were measured in a spinner-magnetometer[7] simultaneously with heating to 800° C. in a nitrogen atmosphere. Each of the thermal demagnetization curves revealed three constituent magnetic moments not obviously related in direction; the differences in their directions were of considerable use in distinguishing them.

(1) The low-temperature moment disappeared at 100° C. in Homestead and 90° C. in Mount Browne. This moment was probably acquired after arrival on the Earth, apparently having been induced by a field comparable with that of the Earth in conjunction with possible heating to a temperature not greater than 100° C.

(2) The medium-temperature component behaved in much the same way as the natural moments of magnetically stable igneous rocks, several of which have also been examined with the magnetometer. This component is largely associated with the magnetite grains, although it finally disappeared at 630° C., some 50° C. higher than the Curie point of magnetite, indicating incomplete distinction from (3).

(3) The high-temperature component had a direction clearly different from (2) and disappeared at 775° C., approximately the transformation temperature of the metal phase (Parry, L. G., private communication).

The difference in character between components (2) and (3) was clarified by repeating the demagnetization measurements after the meteorite samples had been exposed isothermally to a field of 15,000 oersteds and also after cooling from 850° C. in a steady field of 10 oersteds. In each case component (3) appeared in the same direction as in the natural state, but (1) and (2) (no longer distinguishable) were in the direction of the inducing field, at a wide angle from (3). This unexpected and anomalous behaviour of component (3) is difficult to explain. It may be due to strongly anisotropic metallic grains from which a plane of layering might be inferred.

For the present purpose component (2) is the most useful one. For the Mount Browne sample this component has been vectorially subtracted from component (3) and displayed as a function of temperature in Fig. 1 for the three cases of natural

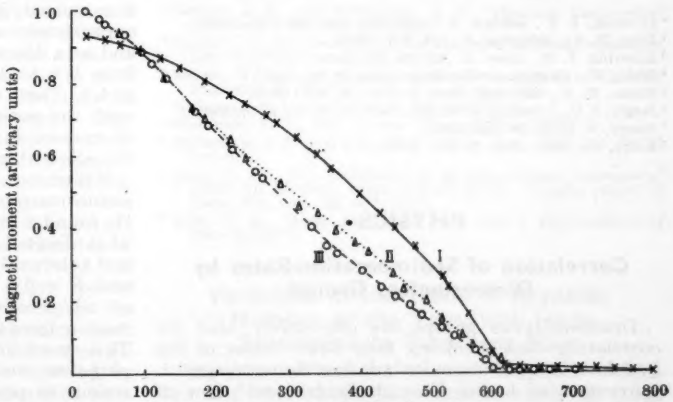

Fig. 1. Thermal demagnetization of Mount Browne chondrite. I, Artificial thermo-remanent moment; II, medium-temperature component of natural moment; III, isothermally induced moment. Curves normalized to coincide at 90° C.

moment (curve II), moment induced isothermally by 15,000 oersteds (curve III), and thermally by cooling in 10 oersteds (curve I). The curves have been normalized to coincide at 90° C.

Since curve III represents thermal demagnetization after saturation, moments induced isothermally by smaller fields would be less resistant to demagnetization and give curves lying below this. The fact that curve II lies above it suggests that the natural moment was induced either thermally or during the course of chemical or phase changes or grain growths, to which the general term chemical magnetization applies. Agreement with curve I, representing the artificial thermoremanent moment, is not very close, so that the natural moment may be due to chemical magnetization; it is known that the latter resists demagnetization more strongly than isothermally induced magnetism but less strongly than thermally induced magnetism[8].

Since it is evident that the chondrites have not been substantially heated or chemically changed after their arrival on the Earth, and that they have thermo-remanent or chemical magnetization, their natural moments must have been induced by extra-terrestrial fields. Also, components (1) and (2) of the natural moments are different, not by virtue of different magnetic constituents in the meteorites but by their having been induced in different fields, (1) being superimposed after (2) was established. Component (1) is evidently terrestrial in origin and component (2) apparently extra-terrestial.

It seems likely that the required extra-terrestrial fields originated in the secondary meteorite bodies themselves. Either these bodies had fluid conducting cores, contrary to the usual conception of them, or else fluid cores are not necessary for the generation of magnetic fields of terrestrial type. A choice between these alternatives may be made when we know whether the Moon has a magnetic field, since it is highly unlikely that the Moon has a fluid conducting core.

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PHYSICS

Correlation of Sedimentation-Rates by Dimensionless Groups

Dimensionless groups are extensively used for correlating data involving fluid flow. Some of the best-known applications include flow through pipes[1–3], movement of bodies through fluids[2–5] and flow of fluids through porous media[5,6]. It is usual to plot a friction factor, ψ, against Reynolds number or a modification of it, B (say), and the relationship thus obtained is of the form:

$$\psi = \frac{K}{B^N} \qquad (1)$$

in which N and K are parameters.

The initial stages in the sedimentation of a suspension[5,7] are frequently characterized by a constant settling-rate, and it has been found that a good description of experimental results[6] is provided by:

$$U = U_0 \varepsilon^n \qquad (2)$$

in which U is settling-rate of the suspension; U_0 is settling-rate of the solids at infinite dilution; ε is porosity of suspension, that is, volume fluid per unit volume suspension ($\varepsilon = 1 - C$, where C is volume concentration of solids). Some approximate values for the parameter, n, are 4·7–5 for streamline flow for spheres, 2·4 for turbulent flow for spheres and 7–10 for rough particles.

If plug flow is assumed to account for the constant settling-rate, by forming force balance equations and using dimensionless groups, it can be shown that:

$$\psi = \frac{\varepsilon^3}{U^2 S} \cdot \frac{\sigma - \rho}{\rho} g \qquad (3)$$

$$B = \frac{U\rho}{(1 - \varepsilon)S\eta} \qquad (4)$$

in which S is specific surface area of solid per unit volume; η is absolute viscosity of fluid phase; σ, ρ are density of solid and fluid phases respectively.

The remaining symbols have their usual meaning and, in equation 4, B is called the Blake or modified Reynolds number. The theoretical model used is perhaps the simplest description of sedimentation, though two refinements were introduced into the derivation of equations 3 and 4. These were: (*a*) the velocity of flow in the interstices of the suspension (U/ε) was used instead of the sedimentation-rate, and (*b*) in place of the usual mean particle diameter, equivalent hydraulic radius of the bed was employed. Consequently, equations 3 and 4 are similar to (and could be considered as extensions of) the Blake-Carman correlation[5,6] for the flow of fluids through porous media. In this, $N = 1$ for laminar flow and equation 1 reduces to Kozeny's equation[5,6], in which $K \simeq 5$. For spheres the equation holds over the porosity-range of approximately 0·4–0·55.

If the relationship between equations 1, 2, 3 and 4 is examined, it can be shown that when $n = 5$ (the approximate value for streamline flow for spheres) and as ε decreases from 0·8 to 0·7, then N increases from 0·9 to 1·1, while K remains almost constant at 4·8. These values for N and K compare favourably with the constants of Kozeny's equation, which is of interest in view of the lower range of porosity for which this equation holds.

Whitmore[9] has reported measurements of sedimentation-rates with two sets of spherical particles. He found $n \simeq 4{\cdot}8$, and though the results are somewhat limited, correlating them with equations 3 and 4 shows that when $\varepsilon = 0{\cdot}75$ and 0·80 then $N = 1$ and $K = 5{\cdot}5$. The value of N remained constant at all porosities, but K increased with porosity, ranging from 6 when $\varepsilon = 0{\cdot}85$ to 13·5 when $\varepsilon = 0{\cdot}95$. This trend may be attributed to departure from plug-flow conditions, which will tend to become more serious as porosity increases. Further work on the sedimentation-rate of spherical particles has been reported by Richardson and Zaki[10], who found $n \simeq 4{\cdot}7$–5. Consequently, a correlation by equations 3 and 4 could be expected.

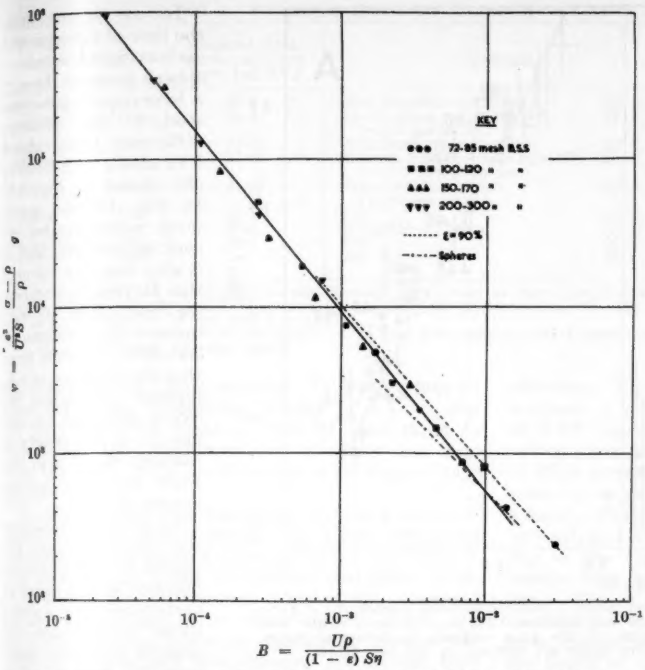

Fig. 1. Sedimentation of rough particles; relation between friction factor and Blake number

Particle shapes other than spherical introduce complications, and shape factors are generally employed to take account of this. However, results obtained by Whitmore[8] for four graded sizes of rough methyl methacrylate powders and correlated according to equations 3 and 4 are shown in Fig. 1. Values of surface area were calculated from the mean particle diameter assuming spheres or cubes, and are probably somewhat smaller than the true values. Thus, if the shape factor is independent of particle size, the true correlation would differ from that shown in Fig. 1 in only one detail, namely, the slope and the relationship of the points to each other would remain unchanged but K would be diminished. In the correlation, $N \simeq 1{\cdot}2$, which is not unexpected because $n \simeq 7{-}9{\cdot}5$, as compared with $4{\cdot}8$ for spheres. The points representing low concentrations of solids again diverge from the general trend but not in such a pronounced manner as with spheres. This may be because rough particles interlock more readily than spheres and as a consequence conditions of plug-flow may still persist at reduced concentrations.

The scope of this method of representation is yet to be investigated, especially with regard to the shape and effective size of the particle. Two important cases are flocculation and the apparent diameter of rough particles carrying fluid on their surfaces. A further possible investigation, which might be of interest, follows from the similarity between the present and the Blake–Carman correlation which would enable the transition from fluid flow through porous media into sedimentation to be followed on a single diagram. This could be considered to be a function of increasing porosity.

It is believed that equations 3 and 4 have not been proposed before, which is somewhat surprising in view of the widespread application of other similar correlations. In connexion with this, Dr. J. F. Richardson (private communication) has pointed out that Minz[11] employed dimensionless groups for dealing with sedimentation-rates; Minz employed the Blake–Carman correlation directly and worked in the Blake number range 0·1–100, where transition from laminar to turbulent flow takes place. He found that when $B = 1$, $N = 0{\cdot}95$ and $\psi \simeq 5$. Consequently, $K \simeq 5$, which compares favourably with the results obtained here.

Finally, it is possible to raise objections to the use of dimensionless methods to describe flow through porous media, since the method is based upon an assumption of dynamic and hence geometrical similarity which cannot hold for a system of particles in which geometrical configuration is varied in order to obtain different porosities. Consequently, as Rose[12] points out, the results may be empirical, but "the method is an extremely powerful tool for preliminary examination of a very difficult problem".

I wish to thank Prof. J. T. Whetton for interest and encouragement, and my colleagues, Mr. H. G. Smith, Dr. A. Jowett and Dr. G. D. Lill, for useful discussion, and also Dr. R. L. Whitmore, of the University of Nottingham, and Dr. J. F. Richardson, of the Imperial College of Science and Technology, London, for their comments on an earlier draft of this communication.

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Variations in the Value of Reynolds Number at the Transition from Streamline to Turbulent Flow

The flow of nitrogen through a porous copper disk has been investigated experimentally at mean pressures of 2–80 atm., and the flow of carbon dioxide through the same disk has been investigated up to mean pressures of 50 atm., at room temperature. The difference in pressure across the disk was never

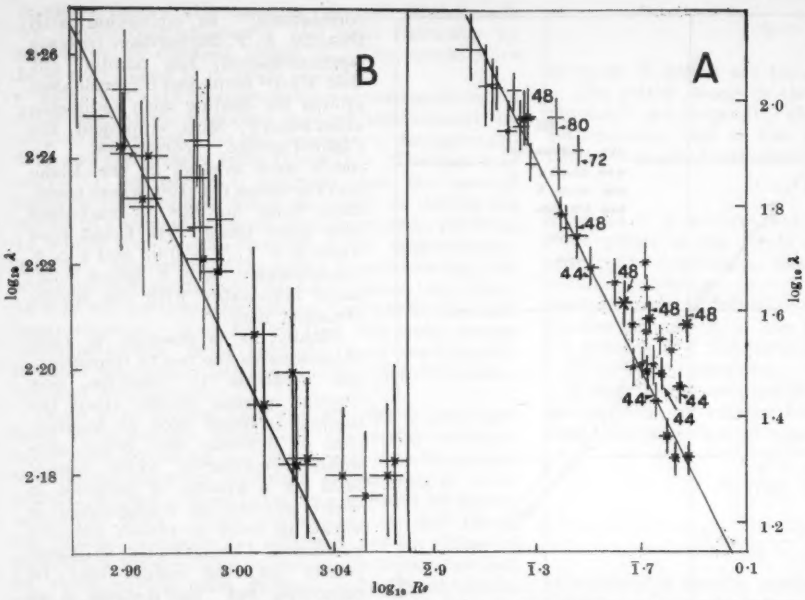

Fig. 1. Graph showing the variation of the friction factor, λ, with the Reynolds number, Re. *A*, For a porous copper disk mean pore radius about 10^{-3} cm. and thickness 0·005 cm.; *B*, for a copper tube about 1 m. long and 0·18 cm. dia. The lengths of the arms represent experimental errors. +, nitrogen; •, carbon dioxide. (Note: The scales are different in the two figures)

more than 0·6 atm. and was as small as 0·2 atm. in some experiments. As the mean pressure was increased from 2 atm. the flow through the disk remained streamline up to mean pressures of nitrogen of about 70 atm. and up to mean pressures of carbon dioxide of about 40 atm., the value of the pressure at which the flow departed from streamline flow being dependent on the pressure difference. Results showing the departure of the flow from streamline flow are given in Fig. 1*A*; some of the mean pressures are shown in Fig. 1 opposite the relevant points; but most pressures have been omitted so as not to confuse the diagram. The straight line represents streamline flow through the disk. Points lying off the straight line are usually attributed to the onset of turbulence; accepting this interpretation if R'_c be the value of the Reynolds number at which turbulence begins then it is apparent from Fig. 1 that (1) R'_c for nitrogen is different from that for carbon dioxide; (2) R'_c for carbon dioxide diminishes as the mean pressure increases.

When the results shown in Fig. 1*A* were first obtained, as an incidental part of a different research programme[1], the results were unusual; but corroborative evidence for variations in the value of Reynolds number at the onset of turbulence has been found since in Lindgren's work[2,3] and in our recent work. Lindgren worked with aqueous solutions of bentonite. He used birefringence to study flow patterns in the solutions as the solutions flowed through a cylindrical glass tube; in addition, he measured drop of pressure occurring in the flow. As the concentration of the bentonite solutions was altered variations were found in the values of Reynolds number at the onset of turbulence which could not be accounted for by changes in the variables occurring in Reynolds number, or by variations in such factors as entry length, which are known to alter the value of Reynolds number at the onset of turbulence.

In our recent work the flow of nitrogen and carbon dioxide at atmospheric pressure through a long copper tube was studied, the pressure difference being about 0·02 atm.; some results are shown in Fig. 1*B*. In Fig. 1*B* the maximum experimental errors are shown, and it is seen that the value of the Reynolds numbers for the onset of turbulence in nitrogen is certainly different from that for the onset of turbulence in carbon dioxide, although the difference is not nearly as marked as it is in the work with the porous copper disk.

In both the tube and the porous disk the values of the Reynolds number at the onset of turbulence are about those quoted for the critical Reynolds numbers for flow in tubes and porous media respectively. That a value for Reynolds number which is so near the value quoted for the critical Reynolds number should vary as the identity of the fluid is altered and also as the pressure is altered in a given fluid suggests a relevant dimension is omitted in the analysis; the temperature is a dimension which is omitted, and it may well be that energy transfer occurs in the gases at what appears to be the transition from streamline to turbulent flow in such a way that the flow is no longer isothermal. But additional experimental and theoretical evidence is required; the problem is: given a piece of apparatus, can the extent of the streamline flow of any compressible fluid in the apparatus be predicted precisely from a series of experiments showing the extent of the streamline flow with one fluid at one given mean pressure?

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Effect of Humidity on the Breakdown of a 1-cm. Homogeneous Field Spark Gap in Air

The effect of humidity on the breakdown voltage of a homogeneous field spark gap in air has been reported in a previous communication[1]. The increase in voltage with humidity agrees with the results of Ritz[2] and Köhrmann[3] for homogeneous fields, but it is greater than the figure of 0·13 per cent increase per mm. mercury of water found by Lewis[4] for a 0·4-cm.

Table 1. Summary of Breakdown Voltage Measurements on Plane Electrodes

Author and date	Measured breakdown voltage of 1-cm. gap (kV.)	Conditions		Type of voltage	Breakdown voltage of 1-cm. gap corrected to dryness at 20° C. 760 mm.
Schumann 1922	31·7	Wet, humidity unknown	20° C.	a.c.	30·8*
Klemm 1923	31·4	About 40 per cent humidity (~ 6·9 gm./cu.m.)	20° C.	a.c.	30·5
Spath 1923	31·55	Wet, humidity unknown	20° C.	a.c.	30·6*
Holzer 1932	31·66	Between 30–80 per cent humidity (~ 5·2–13·8 gm./cu.m.)	20° C.	a.c.	30·9–30·4
Ritz 1932	31·35	Wet, humidity 10 mm. (~ 9·8 gm./cu.m.)	20° C.	a.c.	30·3†
Fisher 1947	30·1	Dry	22° C.	d.c.	30·3
Bruce 1947	30·3	Humidity unknown	20° C.	a.c.	29·7‡
Köhrmann 1956	30·1	Dry	20° C.	d.c.	30·1
Present 1958	—	Dry	20° C.	d.c.	29·9–30·3

* Voltage obtained assuming 40 per cent humidity, but it may be more than this, with the result that the voltage will be even lower From the relative humidity data for Jena (1923) prepared by the Meteorological Office this figure appears to be rather low and a better value may be of the order of 70 per cent humidity.
† This value is obtained from Ritz's work on the humidity correction and it agrees with our value.
‡ Assuming 4 mm. of water vapour.

gap between 2-cm. diam. spheres. It is important to know the actual breakdown voltage of a 1-cm. gap not only from the point of view of attempting to understand the mechanism of a spark but also from the more practical application in high-voltage engineering.

For the purpose of comparison a summary of breakdown voltage measurements for plane electrodes obtained by different workers is given in Table 1. The first column gives the author and date of the publication and the second column the observed breakdown voltage. The third column shows the humidity and temperature conditions of the air, while the fourth and fifth columns specify the type of voltage applied, a.c. or d.c., and the breakdown voltage corrected for humidity and a temperature of 20° C.

The differences between the measurements of column 2 made by the early German workers and the later values are almost ± 2·5 per cent about a mean, and it is difficult to account for these differences purely on grounds of errors in voltage measurements. It must be remembered, however, that little attention was paid to the effect of humidity on the breakdown value before the work of Ritz. Klemm[5] indicated that the humidity was about 40 per cent, Schumann[6] and Spath[7] did not consider it, and Holzer[8] mentioned that the humidity was between 30 and 80 per cent. By using our measured increase of voltage with humidity and assuming a figure of 40 per cent for Schumann and Spath, the corrected values are 30·8 kV. for the former and 30·6 kV. for the latter. Holzer's value for the breakdown voltage is reduced to 30·9 kV. for an assumed humidity of 30 per cent and 30·4 kV. for 80 per cent. Ritz's result is reduced to 30·3 kV. when corrected for 10 mm. of water vapour. Fisher's[9] value for the breakdown of a 1-cm. uniform field gap in dry air has also to be corrected for temperature since the measurements were normalized to 22° C.

The values of the breakdown voltage measured by us lie between 29·9 and 30·3 kV. in dry air at a pressure of 760 mm. mercury at 20° C. The low values in the region of 29·9 kV. were obtained with brass and aluminium alloy electrodes which had been freshly polished. These values, however, increased rapidly to about 30·1 kV. with a little sparking and may be attributed to the formation of oxide layers on the cathode. Another 'conditioning' effect which increased the minimum breakdown from 30·1 to 30·3 kV. was most likely due to changes in the gas, and is noticeable in the present work due to the fact that the electrodes were mounted in an enclosed chamber. The absolute accuracy of the present work is about ± 0·5 per cent and the more stable value of 30·3 kV. agrees reasonably well with the corrected values given in column 5 of the table. Examination of these corrected results shows that all the values lie within a range of approximately ± 1 per cent about a mean. Furthermore, if the results prior to 1932 are ignored, and the lower breakdown values corresponding to the higher humidity is taken for Holzer's results, then the differences are as low as ± 0·6 per cent. This is much smaller than is indicated by the uncorrected values given in column 2 and can almost be accounted for by experimental errors. These limits are based on the assumption that the figure of 30·3 kV. given by Bruce[10] is for dry air. This seems rather unlikely, and even if the humidity was only 4 mm. mercury, then Bruce's value will be reduced to 29·7 kV. for dry air, the lowest value in the table. However, this value does not differ significantly from the low values found in the present work using freshly polished electrodes.

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CHEMISTRY

Stable Configuration of Methyl Groups in Dimethyl Ether

The internal rotation of a methyl group about its symmetry axis, despite the presence of the group in a great variety of organic molecules, has attracted little attention, probably because experimental methods such as dipole moment measurement, etc., are not available for the elucidation of the problem. In the structural determination of molecules containing methyl groups, each group is often considered as a whole rather than as four separate atoms[1]. However, the determination is not complete, unless the

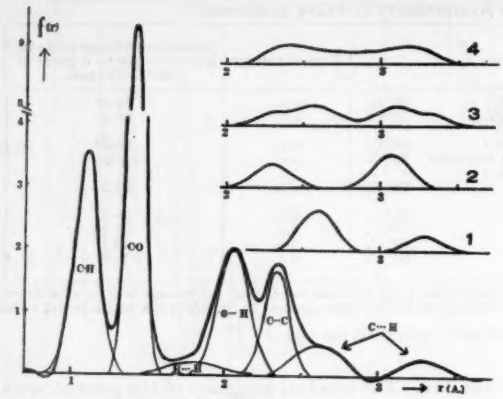

Fig. 1. Experimental radial distribution curve $f(r)$ and the theoretical contributions of C...H distances to it for various models

stable configuration of hydrogen atoms in molecules is taken into account. Recent advances in the experimental technique of electron diffraction by gas molecules have made it possible to determine the values of structural parameters with higher precision than formerly. For the present purpose, a dimethyl ether molecule is perhaps the simplest prototype amenable to the sector-microphotometer method in electron diffraction, because the molecule has non-bonded C . . . H distances which are sensitive to the rotation of methyl groups and contribute appreciably to the total scattered intensity.

The electron diffraction photographs were taken with an apparatus[2] having an r^3-sector and a beam trap. Two camera distances, of 12 cm. and 28 cm., were used, the s-region covering 2–12 and 5·5–30, respectively. The conversion of photographic density into total scattered intensity was made by Karle's method[3]. The molecular term of scattered intensity was evaluated by drawing a smooth background through the total intensity curve on the basis of the usual criteria[3], a correction being made for non-nuclear scatterings[4]. In computing the radial distribution curve shown in Fig. 1, theoretical intensity curves for $s < 2$ and $s > 30$ were joined on to the observed curve. No damping factor was used towards the last steps of successive approximations, because the intensity for $s > 30$ was dominated by contributions from bonded C—O distances which could be determined accurately.

The radial distribution curve has two prominent peaks corresponding to bonded C—O and C—H distances. They are isolated and give definite values, 1·416 ± 0·003 A. and 1·094 ± 0·006 A., for the respective atomic distances. Two mutually overlapping peaks can be assigned largely to non-bonded C...H distances and a non-bonded C...C distance, which leads to a value of 111·5° ± 1·5° for the angle COC. A hump at about 2·6 A. on the right-hand side of the C...C peak and a weak peak at 3·3 A. are due solely to contributions from non-bonded C...H distances, because the contributions from H...H distances between hydrogen atoms belonging to different methyl groups are negligibly small. This gives a clue to the elucidation of the position of the methyl groups relative to the framework. Theoretical curves were therefore calculated for four different models: (1) a model performing restricted rotation about a C_{2v} form as an equilibrium position, with two hydrogen atoms belonging to different methyl groups at the maximum distance apart; (2) the same as (1) except that the two hydrogen atoms are at the minimum distance apart; (3) a model having C_s symmetry, that is, a gear type having a plane of symmetry; and (4) a free-rotation model. These theoretical curves differ from one another to a considerable extent as shown in Fig. 1, and the comparison with the observed curve leads to an unequivocal conclusion that the agreement is best between the experimental curve and the theoretical curve for model 1. One might suspect that the experimental radial distribution curve will be affected by the selection of models, because the theoretical intensity curves were joined on to the observed intensity curve. Examination showed that the experimental radial distribution curve was almost independent of models, on the basis of which the theoretical intensity was calculated for the unobserved s-regions.

In order to confirm the result, theoretical intensity curves were computed for the above-mentioned models with their parameters varied over appropriate ranges and compared with the experimental intensity curve. It was found that the curve for model 1 gave the smallest average deviation of s/s_{exp}. A further check was made by examining the observed intensity at small angles by Morino and Kuchitsu's method[5] for the study of internal rotation. Only model 1 satisfied the required criterion. Hence it is concluded that the internal rotation in this molecule is not free, but that the molecule exerts restricted rotation about the stable configuration having C_{2v} symmetry. Details of this work have been submitted to the *Journal of Chemical Physics*.

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Catalytic Action of Copper in the Alkaline Autoxidation of Cellulose at Low Alkali Concentration

Bell and Gibson[1] have suggested that the degradation suffered by cellulose in contact with rusting iron is the result of autoxidation catalysed by the iron itself under the alkaline conditions resulting from the process of corrosion. Very little information is available concerning the influence of metals in the autoxidation of cellulose at the low alkali concentrations likely to be involved in such a system. It may therefore be of some interest to describe the results of an investigation in which it was found that copper has apparently an unexpectedly high catalytic effect in the reaction of cellulose with oxygen at low alkalinities.

Small hanks of commercially bleached cotton yarn, soaked in 0·2 *M* copper sulphate solution, were

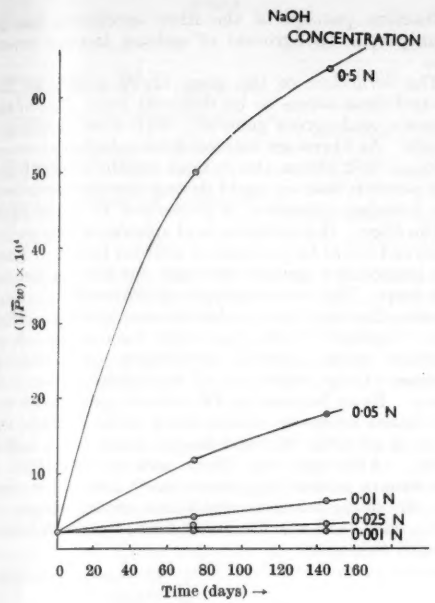

Fig. 1

immersed in sodium hydroxide solution to precipitate the copper, giving a deposit of about 2·5 per cent copper on the yarn. The hanks were then variously conditioned by three immersions of 15 min. each in one of a range of solutions of sodium hydroxide varying in concentration from 0·5 *N* to zero, thus giving a series of specimens containing differing small quantities of free alkali. The hanks were centrifuged, dried and stored in the dark in loosely capped bottles. In additional experiments with cotton containing 'B.D.H.9011' indicator, it was shown that on exposure to the atmosphere the free alkali was converted beyond the stage of carbonate in less than 1¼ hr. even with the highest alkali concentration used.

At intervals the weight–average degrees of polymerization ($\overline{P}w$) of the specimens impregnated with copper were obtained[2,3] from the viscosity in cuprammonium hydroxide solution. Fig. 1 shows the variation of reciprocal $\overline{P}w$ with time. Such a plot gives a direct measure of the reaction-rate provided that the ratio of $\overline{P}w$ to $\overline{P}n$ (the number-average degree of polymerization) remains constant, a condition known to obtain in the heterogeneous acid hydrolysis of cotton[4].

To a first approximation the rate of alkaline autoxidation of cellulose may be taken as proportional[5] to the concentration of sodium hydroxide below 5 *N*. It is accordingly possible to obtain from Davidson's work[6] an estimate of the rate at which alkali-impregnated cotton may be expected to autoxidize without added catalyst at low concentrations of alkali, in terms of the time required to reach a given extent of depolymerization. The rate of degradation observed with 0·05 *N* sodium hydroxide is then found to be greater than that calculated from Davidson's results by a factor of approximately 4 if absorption of carbon dioxide is not taken into account. Assuming conversion to carbonate, the calculated decrease in *p*H corresponds to an increase in catalytic factor to approximately 80, while the true value must be substantially higher than this in view of the inevitable absorption of carbon dioxide beyond the stage of carbonate. Other workers[6,7] concerned with alkali concentrations of 5 *N* or higher have found that less than a ten-fold increase in rate can be brought about by the addition of metals such as iron, cobalt, nickel, manganese or copper. This remarkable difference in catalytic behaviour cannot be accounted for with certainty on the basis of the results at present available. However, one possible explanation is that at high concentrations of alkali, as the concentration of catalyst is increased, the reaction-rate may become dependent on the availability of oxygen and thus eventually independent of the concentration of catalyst (such independence is in fact observed[6,7]). This limitation would be less likely to apply in the present system, where the rates of reaction are relatively low.

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Electron Microscopy of Sodium Laurate

Although a number of papers have been devoted to the electron microscopy of soaps deposited from aqueous solution[1–4], none has reported a study at high resolution. It is the purpose of this communication to discuss some preliminary results of an investigation into the fine structure of sodium laurate using high-resolution electron microscopy and electron diffraction.

Sodium laurate was made from pure lauric acid. Samples for electron microscopy were prepared by allowing a drop of solution to dry down on a carbon-coated electron microscope grid. To minimize thermal damage in the electron beam the specimens were shadow-cast with gold–palladium alloy at an angle of $\tan^{-1}\frac{1}{2}$. Adjustment of the *p*H of the solution to 10·0 made no difference to the structure of the soap.

The form of the deposit varied with the concentration. From solution at low concentration ($< 0{\cdot}02$ per cent) the soap crystallized into well-defined needles which at high magnification showed no characteristic substructure. As the concentration was increased beyond about 0·05 per cent a close network of ribbon-like fibres was formed (Fig. 1), the thickness of the ribbon being perpendicular to the substrate. This is in accordance with the findings of other workers. At high magnification these fibres appeared to consist of an array of cylinders or spheres approximately 30 A. in width arranged in lines along the fibre axis (Fig. 2); the periodicity across the fibre was 50–80 A. This regularity of fibre substructure was also shown by sodium laurate dispersed by mulling in *n*-butanol[5] and by carbon replicas of soap fibres dried down on mica. While it is likely that the contrast in the image is due directly to agglomerated particles of shadowing metal, the regularity in the structure indicates that agglomeration on to some unit within the fibre is occurring.

Fig. 1. Low-magnification micrograph of sodium laurate fibres grown from air-dried aqueous solution. (× *c.* 8,500)

Fig. 2. High-magnification micrograph of part of the same specimen showing the fine structure within the fibres. (× *c.* 70,000)

It is generally considered[5] that in a soap crystal the molecules are packed with the long chains parallel to the short axis of the crystal, and it has been suggested that in fibres the chains are similarly packed[3]. Using low intensity and low magnification, we have obtained excellent powder patterns corresponding to *hk*0 reflexions only from large areas of both fibre and crystal specimens, which would support the above view that the structures of crystals and fibres are similar.

On the other hand, Bondi and co-workers[6] have proposed an alternative fibre structure in which the chains of the soap molecules are aligned approximately parallel to the width of the ribbon, so explaining the tendency for pure sodium soaps to cleave along the fibre axis. Our electron microscopic observations are more in accord with such a structure. Thus, in Fig. 2, the fibres are made up of ultimate units 30 A. in width (twice the length of a sodium laurate molecule) and the tendency for cleavage, sometimes to fibrils only a few units in width, is clearly illustrated.

We have used selected area electron diffraction of single fibres and crystals in an attempt to resolve this anomaly. Spot patterns of *hk*0 reflexions were obtained from soap crystals, although the crystalline order disappeared rapidly in the electron beam, whereas only diffuse bands were obtained from fibres. It seems possible, therefore, that the large-area diffraction pattern of the fibre specimens was due mainly to a background of sodium laurate crystallites.

The structure of the soap fibres which we have studied thus seems to be different from that of soap crystals, and agrees generally with that proposed by Bondi. As fibres are formed from solution at concentrations well above the critical micelle concentration it is possible that on rapid drying out (as in our work) the micellar character is preserved to some extent in the fibre: the cylinders and spheres which we have observed could be micelles of sodium laurate. Ezaki[7] has proposed a similar structure for fibrous commercial soap. The one technique which could, in theory, resolve this problem—selected-area electron diffraction combined with dark-field microscopy—is not possible under normal conditions of microscopy because of the rapid loss of crystalline order in the fibres. Even large-area diffraction patterns at very low beam intensity disappeared more quickly than those of paraffin wax and fats of much lower melting point. Although the effect cannot, therefore, be due simply to heating, preliminary tests have shown that the fibres are more stable in a cooling stage.

We wish to thank Unilever, Ltd., for permission to publish this work.

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Interaction between Organic Hydroxy Acids and Germanic Acid in Aqueous Solution

A previous communication[1] described the formation in aqueous solution of a number of definite stoichiometric complexes of germanic acid and organic hydroxy acids. These complexes were identified mainly by conductimetric, polarimetric and *p*H measurements. Further work has been carried out on other organic hydroxy acids using the same procedures, and this has resulted in the identification of five more complex acids of germanium. Acids identified are summarized in Table 1.

Crystallization of the complex acids of germanium has proved a difficult task owing to the very high solubility of these compounds in water. Crystalline complex acids in a high state of purity have only

Table 1

Parent hydroxy acid		Mol.Ge/acid
Glycollic acid	$HO.CH_2.COOH$	1 : 3
Phenyllactic acid	$C_6H_5.(CH_2).C(OH).COOH$	1 : 2
Bromomandelic acid	$C_6H_4Br.CH(OH).COOH$	1 : 3
Benzilic acid	$C_6H_5(C_6H_5).C(OH).COOH$	1 : 2
α-Hydroxy-caprylic acid	$CH_3.CH_2.CH_2.CH_2.CH(OH).COOH$	1 : 2

Table 2

Complex acid	Empirical formula
Germanomandelic acid	$C_{14}H_{20}O_{13}Ge$ (I)
Compound obtained by heating (I) to 140° C.	$C_{14}H_{14}O_9Ge$ (II)
Compound obtained by heating (I) to 190–200° C.	$C_{14}H_{12}O_8Ge$ (III)
Germanobenzilic acid	$C_{28}H_{22}O_7Ge$ (IV)
Germanohydroxycaprylic acid	$C_{16}H_{32}O_9Ge$ (V)
Compound obtained by heating (V) to 150° C.	$C_{16}H_{30}O_7Ge$ (VI)

been obtained when the complexing acid contains a benzene ring or a large number of carbon atoms, for example, mandelic acid, benzilic acid and α-hydroxycaprylic acid.

Results of thermogravimetric and chemical analyses have been combined and empirical formulæ assigned to the crystalline acids (Table 2).

It will be noticed that the three complex acids of germanium and mandelic acid differ from each other by $2H_2O$. The fact that the four molecules of water are given off in two stages seems to indicate that the first two molecules are combined in a different manner from the second two. These observations do not agree with those reported by Mme. O. Vartapetian[2], who did not report any water of crystallization for the complex acid.

A molecule of water of crystallization was found for germanohydroxycaprylic acid, but none for the complex acid derived from germanium and benzilic acid.

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Some Methods for the Purification of Sugar Sulphates

Prompted by the recent publication of a communication on the synthesis and purification of certain sugar sulphates[1], we wish to report on some methods for the preparation and purification of these esters which we have found useful in a wider context.

Sulphation of hexoses, or of methyl glycosides, is usually accomplished by the use of chlorosulphonic acid or of the pyridine–sulphur trioxide complex[2]. We have found the latter reagent to be the more satisfactory if the reaction is carried out at a temperature of 60–70° C. for 9–20 hr., using 3 moles of reagent per mole of sugar. Under these conditions comparable amounts of mono- and di-sulphate are produced, but if one hydroxyl group only is available for sulphation the proportion of reagent can be reduced to 1·5 moles.

The product resulting from the direct sulphation of hexoses and glycosides consists of a mixture of non-sulphated sugar, mono- and di-sulphate. This mixture is difficult to separate by methods of precipitation or fractional crystallization and so our attention was directed towards chromatographic and ion-exchange methods. The successful application of ion-exchange resins in the separation of mixtures of sugar phosphates[3] suggested that this method might be employed for separating sugar sulphates; but a detailed investigation led to the conclusion that, while some separation is possible, the method is tedious and the ultimate yield of pure fractions small.

Lloyd[1] has reported that a satisfactory separation of these mixtures is obtained if the sulphuric acid esters derived from the salts are eluted from cellulose columns using a butan-1-ol/acetic acid/water solvent system. We have also found column chromatography to be of value in this respect. In one method, the mixture obtained by direct sulphation of the sugar (galactose, glucose or mannitol) is adsorbed as the neutral barium salts on a column of cellulose powder (Whatman, Standard Grade, previously washed with water, alcohol and ether and dried at 35° C.). Elution with ethanol/acetic acid/water (80 : 1 : 9 by volume) is continued until the unchanged sugar and monosulphate have been separately removed, and thereafter water is used as solvent to hasten elution of the disulphate. In a typical fractionation by this method, the mixture (5 gm.) obtained by direct sulphation of galactose yielded galactose (0·6 gm.), barium galactose monosulphate $[\alpha]_D^{21}$ + 33° (1·1 gm.), and barium galactose disulphate, $[\alpha]_D^{26}$ + 38° (1·7 gm.), each chromatographically and ionophoretically pure.

In the case of the methyl glycosides of glucose and galactose, the separation of unchanged glycoside from glycoside monosulphate is not so complete, although the glycoside disulphate is readily obtained pure. The separation of the glycoside and the glycoside monosulphate can be effected afterwards by the use of ion-exchange resins. Two columns are connected in series, the first containing 'Zeo-Karb 225' (H^+ form) and the second containing 'De-acidite *F*' (free base). Percolation of the mixture of barium salts through these columns results in absorption of the monosulphate on the anion-exchange resin (second column) from which the unchanged methyl glycoside is removed by washing with water. Subsequent irrigation with 2 *N* ammonium hydroxide elutes the glycoside monosulphate, which is obtained as the ammonium salt by cautious evaporation of the eluate *in vacuo*. Similarly, the mixture obtained by sulphation of 1 : 2-3 : 4 di-O-*iso*propylidene-D-galactose is resolved by ion-exchange resins into unchanged starting material and the ammonium salt of the 6-sulphate.

The technique of partition chromatography using 'Celite' as supporting medium[4] can also be used to resolve mixtures of glycosides and their monosulphates. We have used acid-washed 'Celite 535' (Johns-Manville Co.) as adsorbent with butanol saturated with water as eluting solvent to separate a mixture of α-methyl glucoside and its monosulphate. This method suffers from the disadvantage that the columns have a rather low loading capacity.

For the routine qualitative examination of sulphation mixtures, the method of paper-ionophoresis has the advantages over paper-chromatography of speed and simplicity. A satisfactory resolution of galactose, its monosulphate, and its disulphate is obtained on Whatman No. 54 paper, using 0·067 *M* phosphate buffer (*p*H 6·8) as electrolyte and a potential gradient of 10 volts/cm. for 3–4 hr. Carbohydrate zones are detected by the silver nitrate reagent of Trevelyan, Procter and Harrison[5]. Similar results are obtained with other sulphation mixtures, but the method is not capable of separating two monosulphates.

We wish to thank Prof. Stanley Peat for his advice and the National University of Ireland for the award of a travelling studentship to one of us (M. J. C.).

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SOIL SCIENCE

Stability of Soil Crumbs

Tiulin[1] showed that the stability of soil crumbs in water is greater from grassland than from corresponding arable soils. Since then, much work has been done to find out how this increase in stability is brought about by the soil organic matter. A review of this work is given by Baver[2]. In recent years it has been discovered that small additions to the soil of various synthetic polymers, called soil conditioners, also stabilize soil crumbs. The polymers can be either non-ionic, such as polyvinyl alcohol[3], or carboxylated polymers, such as polyacrylic acid[4].

It is now suggested that both soil organic matter and soil conditioners increase the stability of soil crumbs by linking together the principal constituents of the crumbs, the domains of orientated clay and the quartz particles. The linkages will be from the surfaces of the quartz to either the external basal or external edge surfaces of the clay domains, forming inter-crystalline or peripheral complexes[5,6] respectively (Fig. 1).

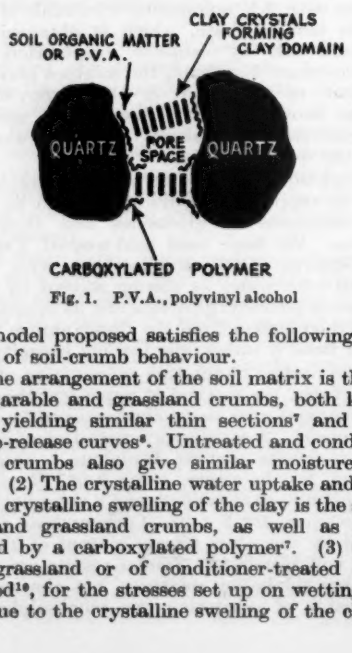

Fig. 1. P.V.A., polyvinyl alcohol

The model proposed satisfies the following known features of soil-crumb behaviour.

(1) The arrangement of the soil matrix is the same in both arable and grassland crumbs, both kinds of crumbs yielding similar thin sections[7] and similar moisture-release curves[8]. Untreated and conditioner-treated crumbs also give similar moisture-release curves[9]. (2) The crystalline water uptake and, therefore, the crystalline swelling of the clay is the same in arable and grassland crumbs, as well as crumbs stabilized by a carboxylated polymer[7]. (3) Slaking of the grassland or of conditioner-treated crumbs is reduced[10], for the stresses set up on wetting a dry crumb due to the crystalline swelling of the clay will be shared between several clay domains, through their linkages to the same quartz particles. (4) If the clay is sodium-saturated, the diffuse double-layer swelling is reduced sufficiently by the proposed quartz–organic material–clay linkages to prevent dispersion of the grassland or conditioner-treated crumbs in water[11]. (5) Remoulding grassland or conditioner-treated crumbs by breaking further quartz–clay linkages reduces the strength of the crumbs as measured by any conventional wet sieving or dispersion technique[12].

The model also offers a satisfactory way of accounting for the physical action and economy of soil conditioners. When a solution of a soil conditioner is added to a dry crumb, the consequent slaking will break the weakest clay–quartz bonds, so producing readily available sites for adsorption of the polymer. These sites are, at the same time, the most advantageous for increasing crumb stability.

The detailed presentation of this model with some of its consequences will be published elsewhere[13]. The model is incomplete, in that the chemistry of the linkage of the organic material to the quartz is not specified. There are other methods of stabilizing crumbs, for example, by using quaternary ammonium salts to inhibit the crystalline swelling of the clay[14].

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Latent Interparticle Forces in Clays

Work in colloid science is usually concerned with clays in suspension, where external stresses are negligible. Experimental work in soil mechanics has shown that in consolidated and compacted clays both the existing external effective stress and the stress history are most important in determining soil properties[1,2].

If the pressure of pore water in a saturated clay is zero, the external stress σ_E must be balanced by a net intergranular repulsion σ_I:

$$\sigma_E - \sigma_I = 0 \qquad (1)$$

Fig. 1 shows the virgin consolidation curve *ABCDE* and three rebound curves *BF*, *CG* and *DH* for a clay initially prepared at a high water content. Each point on the virgin consolidation curve and on any rebound curve is an equilibrium point with zero pressure of pore water. At any voids ratio e_1, σ_E may have any value within a wide range (for example, σ_a, σ_b, σ_c, etc.), the maximum being the virgin consolidation value σ_{NC}. It follows from equation (1)

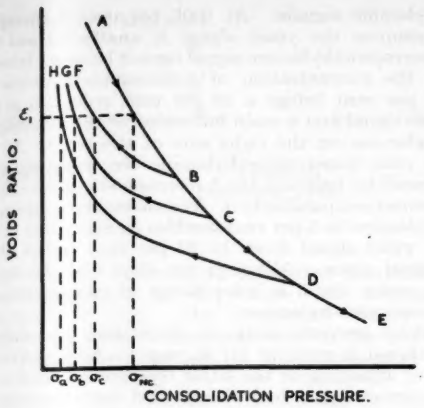

Fig. 1

that σ_I must also have a range of possible values at any voids ratio, with a maximum value $\sigma_{I\max.}$ at the virgin consolidation condition. During rebound the repulsive stress is less than $\sigma_{I\max.}$ so that an additional internal attractive stress σ_{AL} is acting. Equation (1) becomes :

$$\sigma_E - \sigma_{I\max.} + \sigma_{AL} = 0 \qquad (2)$$

At any voids ratio, σ_{AL} will have a maximum possible value $\sigma_{L\max.}$ This is termed the total latent stress. The active portion at any time, σ_{AL}, is the active latent stress and the inactive portion $(\sigma_{L\max.} - \sigma_{AL})$ is the latent stress σ_L.

This attractive stress associated with swelling may arise from particle orientation or from the fact that interparticle forces are not only a function of particle spacing but also of the previous history of particle spacing. Orientation is difficult to support for isotropic consolidation and rebound, and the second possibility is more likely.

In a normally (that is to say, virgin) consolidated clay the latent interparticle forces are completely inactive, and in a heavily prestressed clay they are completely active. In the former case an applied shear stress is resisted by the latent forces becoming active between particles with increasing spacing due to the shear strain, and in the latter case it is resisted by the active latent forces becoming absorbed between particles with decreasing spacing. This leads to a decrease in volume in normally consolidated clays and an increase in volume or dilation in heavily prestressed clays. This behaviour during shear is well known for clays.

Ultimately a unique state is reached, regardless of the initial condition, where the latent forces are fully active between one half of adjacent pairs of particles and completely inactive between the other half. This gives a unique internal and, hence, external stress condition σ_{CVR} for any voids ratio. Experimental evidence for this has been published[3,4].

From the theory of latent interparticle forces it can be shown that the shear strength on an interface is given by the expression :

$$s = \mu(2\sigma_{NC} - 3\sigma_{CVR}) + \mu\sigma_n \qquad (3)$$

where σ_n is the direct effective stress on the interface.

Thus, the strength is composed of two portions : $\mu(2\sigma_{NC} - 3\sigma_{CVR})$, which depends only on voids ratio ; and $\mu\sigma_n$, where μ is an arbitrary constant independent of voids ratio. These portions correspond with Hvorslev's[1] true cohesion and true friction, respectively, but it can be seen from the theory above that these do not represent two different origins of strength. A form of equation (3) suitable for triaxial tests has given excellent agreement with results from Weald clay and London clay.

As latent forces are probably present in all materials which can resist shear stress, it is reasonable to look for their origin in the universal London – van der Waals attractive forces. When two atoms approach each other there may result a mutual disturbance of electron clouds, which is not reversible when separation of the two atoms is again increased. This may result in an attractive force tending to oppose the separation of the atoms.

A discussion of the role of latent interparticle forces in clays will shortly be published elsewhere.

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BIOCHEMISTRY, PHYSIOLOGY and MEDICAL SCIENCES

Radiation Protection and Free Radicals

Free radicals formed in biological materials by ionizing radiation may be detected under the proper conditions by paramagnetic resonance techniques. Possibly such free radicals contribute, directly or indirectly, to the radiation damage suffered by living organisms. The various chemicals which have been found to increase the survival of organisms subjected to large doses of radiation may provide protection by action on the free radicals or by some more direct action on the substance of the organism. This report describes experiments made to see if paramagnetic resonance detection of free radicals could be used to study chemical protection against ionizing radiation.

The paramagnetic resonance equipment uses conventional microwave circuitry[1] operating at 9,000 Mc./sec. and dual modulation of the magnetic field[2]. Yeast suspensions were chosen for study because they survive freezing and are easy to handle. β-Mercaptoethylamine was the protective chemical used. Small samples of the material to be examined were quickly frozen after mixing and were irradiated at liquid-nitrogen temperature in a cobalt-60 gamma chamber, then transferred to unirradiated sample tubes for the paramagnetic resonance measurements at 77° K.

On irradiating a suspension of yeast in water, we found the expected doublet resonance due to the irradiated water and a broad line of 25 gauss width near $g = 2{\cdot}00$. An irradiated solution of β-mercaptoethylamine also showed the water doublet and a 25-gauss line at only a slightly higher g-value—too small a difference to distinguish the yeast from the β-mercaptoethylamine with both present. It seemed possible that the width of these lines was a result of

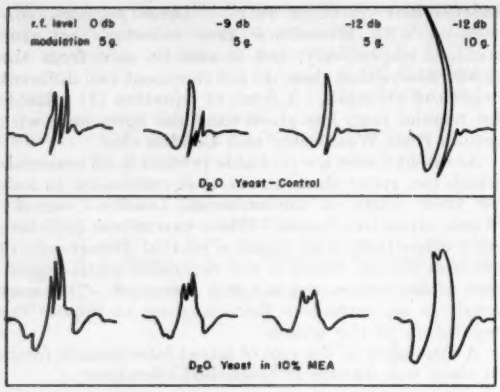

Fig. 1. Saturation effect on yeast signal. Samples Co-60 γ-irradiated 1 hr. at 77° K. for 150,000 r. total dose. Observed at 77° K. MEA, β-mercaptoethylamine; r.f., radio frequency; db, decibels

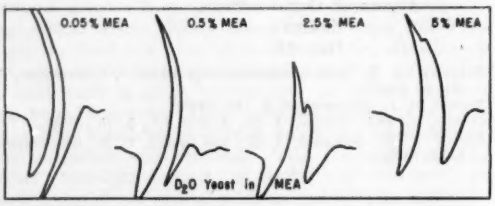

Fig. 2. Effect of β-mercaptoethylamine concentration on yeast and β-mercaptoethylamine signal intensity. MEA, β-mercaptoethylamine. Sample treatment as for Fig. 1

unresolved hyperfine structure due to adjacent hydrogens of the radical. If this were the case, replacing hydrogen with deuterium would narrow the line because the deuteron has a smaller nuclear moment than the proton. We were therefore fortunate in being able to get a generous supply of yeast (*Saccharomyces cerevisiae*) grown in deuterium oxide. (We wish to thank Harry L. Crespi of this Laboratory for the deuterium-grown yeast used in these experiments.) This, when irradiated, gives a signal only 9 gauss wide in addition to the water signal, which is now a triplet (deuteron spin = 1).

Fig. 1 shows how their differing saturation properties may be used for suppressing the water signal and enhancing the yeast signal. In the upper row, beginning on the left with maximum radio-frequency power incident on the sample and the magnetic field modulation adjusted for optimum signal, as the ratio-frequency power is reduced the water triplet is seen to diminish and the yeast line to increase in intensity. The right-hand trace shows an additional increase in the yeast signal by increasing the magnetic field modulation. The lower row shows the same sequence for a sample having 10 per cent by weight β-mercaptoethylamine added before irradiation. On the left is the water triplet sitting on top of the broad β-mercaptoethylamine line. As power is reduced the triplet diminishes, the β-mercaptoethylamine signal remaining constant. On the right, increasing the modulation increases the β-mercaptoethylamine signal. The yeast signal is seen as a small pip on the side of the β-mercaptoethylamine line, indicating, due to the presence of the β-mercaptoethylamine, a decrease in the number of yeast free radicals.

Fig. 2 shows the effect of concentration of β-mercaptoethylamine on both yeast and β-mercaptoethylamine signals. At 0·05 per cent β-mercaptoethylamine the yeast signal is unaffected and the β-mercaptoethylamine signal cannot be seen. Increasing the concentration of β-mercaptoethylamine to 0·5 per cent brings a 10 per cent reduction in the yeast signal and a small indication of the β-mercaptoethylamine on the right side of the trace. At 2·5 per cent β-mercaptoethylamine the yeast signal is reduced by half and the β-mercaptoethylamine signal becomes comparable to it. Increasing the β-mercaptoethylamine to 5 per cent doubles its signal and brings the yeast signal down to 20 per cent or less of its original value. Although not shown in this figure, the water signal is independent of concentration of β-mercaptoethylamine.

From previous work we knew that free radicals produced in water at 77° K. were unstable at 125° K. After annealing at the latter temperature for 1 min., the water signal had disappeared but there was no change in the yeast or β-mercaptoethylamine signals.

We have then: (1) The presence of β-mercaptoethylamine inhibits free radical formation in irradiated yeast. (2) The $\frac{1}{2}$ min. required to add β-mercaptoethylamine to yeast and freeze is time enough for the protection to be established. (3) The β-mercaptoethylamine has no effect on the number of radicals formed in the water of the suspensions. (4) The water radicals, on gaining mobility at 125° K., do not react with the yeast radicals or β-mercaptoethylamine radicals. These observations support the view[4] that the protective effect is not primarily due to inactivation of the products of irradiation of water but rather to direct action of the protective agent on radiosensitive constituents, for example, cell protein.

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Absence of a Relation between Lipogenesis and Ketogenesis *in vivo*

In the normal liver acetyl-coenzyme *A* is formed from glucose, fatty acids and the keto-acids produced by deamination and transamination of amino-acids. It is removed by oxidation, by fatty acid synthesis and, to a small extent, by ketone body formation (Fig. 1). Lipogenesis is defective in the livers of diabetic and fasting animals, a block occurring in the path of conversion of acetyl-coenzyme *A* to fatty acids[1]. Formerly, many workers related the development of ketosis to a diminished rate of oxidation of acetyl-coenzyme *A*, due to a possible lowering in the level of oxaloacetate. Lately, as a result of experiments *in vitro*, increased ketogenesis has been attributed to a diversion in the utilization of acetyl-coenzyme *A* (or acetoacetyl-coenzyme *A*) from fatty acid synthesis towards the formation of ketone bodies[2–4]. Stadie[4] has advanced the hypothesis that the supply of reduced triphosphopyridine nucleotide, which depends upon the rate of glucose metabolism via the hexosemonophosphate 'shunt', regulates fatty acid synthesis and, consequently, ketogenesis.

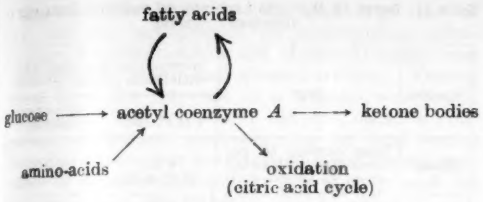

Fig. 1

There is little evidence to show that diminished hepatic lipogenesis is responsible for increased ketogenesis *in vivo*. The lipogenesis theory of ketone-body formation lays emphasis on the under-utilization, rather than on the over-production of acetyl-coenzyme *A* by the liver. However, it is difficult to explain, other than by accelerated oxidation of fatty acids (giving rise to over-production of acetyl-coenzyme *A*), the enormous formation of ketone bodies which is necessary to account for extra hepatic utilization-rates representing 50–96 per cent of the body's oxygen consumption during starvation[5], or for the very heavy ketonuria of severe diabetics[2]. It is difficult to visualize how restoration of the normal rate of hepatic lipogenesis would have more than a moderating influence under these conditions. Since lipogenesis is defective in the livers of animals fed diets devoid of carbohydrate[1], the following experiments with rats on an all-fat diet are relevant to this problem.

Female rats (200 gm.) were fasted for 24 hr. and then given filtered butter-fat *ad libitum* for six days. Experimental details have been published previously[6]. The ketonæmia initiated by starvation continued to rise on feeding fat, but in animals consuming approximately 6 gm. a day a marked reduction was observed after the first day of feeding (Fig. 2). In contrast the ketonæmia of rats which ate less of the diet remained elevated. The ketonæmic responses of animals consuming 6 gm. a day fell into two categories. In one, illustrated by rat *A* (Fig. 2), there was a return to within the normal ketonæmic range, usually on the fifth day of feeding fat. The other, illustrated by rat *B* (Fig. 2), is typical of animals showing a higher initial ketonæmia which dropped afterwards but remained slightly elevated on the fifth day. There was a tendency for the ketonæmia to rise a little in all animals on the sixth day of feeding.

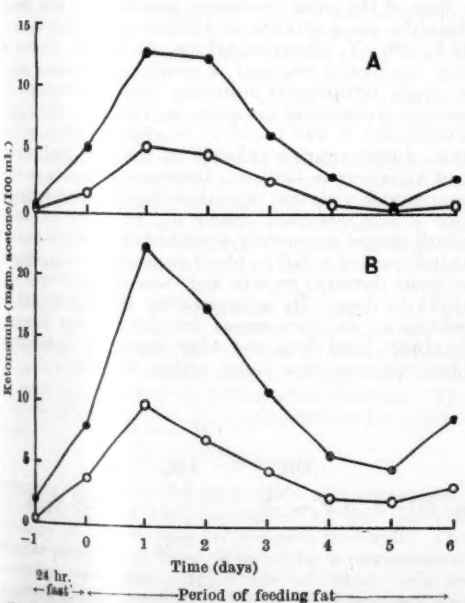

Fig. 2. The course of ketosis in rats starved for 24 hr., which then consumed approximately 6 gm. of butter-fat per day. ●, β-Hydroxybutyric acid; ○, acetone plus acetoacetic acid

The observation of a much reduced ketosis and sometimes its abolition under conditions in which fatty acid synthesis is considered to be defective provides direct evidence that a reduced rate of hepatic lipogenesis is not, necessarily, the major cause of ketosis *in vivo*.

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Stability of Cholinesterase of the Electric Eel

A convenient source of the enzyme acetylcholinesterase occurs in the electric organ of the electric eel, and preparations of a high degree of purity have been obtained from it[1]. Because of the high activity of these preparations and the sensitive methods available for the estimation of enzymatic activity, appreciable dilutions of the enzyme must often be made. It has been found that dilution causes a rapid loss of enzymatic activity, and the addition of an inert protective protein such as gelatine has been recommended[1]. Further studies[2] have revealed that low ionic strengths also produce inactivation and that protection is afforded by plasma albumen[2].

Present investigations into this effect have shown that inactivation in dilute enzyme solutions is primarily a surface phenomenon. Because of the obvious importance of this observation in the preparation and estimation of this enzyme, it is felt that this fact should be emphasized.

The sample was one kindly supplied by the U.S. Army Chemical Centre, Edgewood, Md. and had an activity of 46 gm. of acetyl choline/hr./ml. at 37° C., determined manometrically. It contained 3·97 mgm. of protein/ml. in approximately 6 per cent ammonium sulphate. This sample has remained stable and of the same activity over a period of 1½ years when kept at about 3° C. Enzymatic activity was estimated manometrically using the following conditions: 1·5 ml. 0·05 *M* sodium bicarbonate, 0·5 ml. 0·6 *M* sodium chloride, 0·1 ml. 0·6 *M* magnesium chloride, 0·1 ml. 3 per cent bovine plasma albumen, 0·1 ml. 0·3 *M* acetyl choline bromide, an aliquot of the enzyme solution and water to give a final volume of 3·0 ml. The gas phase was 5 per cent carbon dioxide in nitrogen, which gave a *p*H of 7·43 at 37° C.

Stock enzyme solution was diluted 2,000 times in different solutions, and the activity estimated after two different treatments and compared with controls diluted in the same solutions. In one treatment the

solutions were shaken in small stoppered tubes for 1 hr. at room temperature, while the other treatment consisted of bubbling nitrogen through the solutions for 30 min.

The diluting mediums were as follows: *a*, 6 per cent ammonium sulphate solutions adjusted to *p*H values of 5·4, 7·4 and 9·0; *b*, 0·1 per cent bovine plasma albumen, or gelatine; *c*, 0·02 *M* veronal buffer of *p*H 7·4 containing 0·3 *M* potassium chloride and 0·1 per cent bovine plasma albumen; and *d*, 0·3 *M* potassium chloride.

The results of both treatments are shown in Table 1.

Table 1. Loss of Enzymatic Activity

Solution	Treatment	
	Nitrogen bubbling (Activity lost, per cent)	Shaking (Activity lost, per cent)
a	85–97	75–95
b	2	2
c	0	0
d	95	90

It is clear that, in either solutions *a* or *d*, shaking or bubbling by nitrogen rapidly inactivates the enzyme. This inactivation would appear to be a surface phenomenon and not an oxidation process. The dilute control solutions in ammonium sulphate do not show any appreciable loss of activity if care is taken to avoid excessive agitation in their preparation. Protection is afforded to the enzyme by either bovine plasma albumen or gelatine. It is standard practice in this laboratory to make dilutions of acetylcholinesterase in the veronal buffer solution *c* in which the enzyme is stable for 1–2 weeks when kept in the cold.

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Dec. 8.

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Neuromuscular Blocking Agents of Short Duration

For a number of years we have been interested in the neuromuscular blocking properties of *bis*-onium compounds derived from substituted tropane nuclei, in which linking of the quaternary nitrogens was effected by a polymethylene or aralkyl chain. We observed that such compounds produced a flaccid paralysis on injection into chicks but tended to be long acting. This observation led to the preparation of a series of similar compounds (Fig. 1) in which the linking chain contained two ester-groupings as in suxamethonium. The latter is known to produce short-acting block which is, however, of depolarizing character.

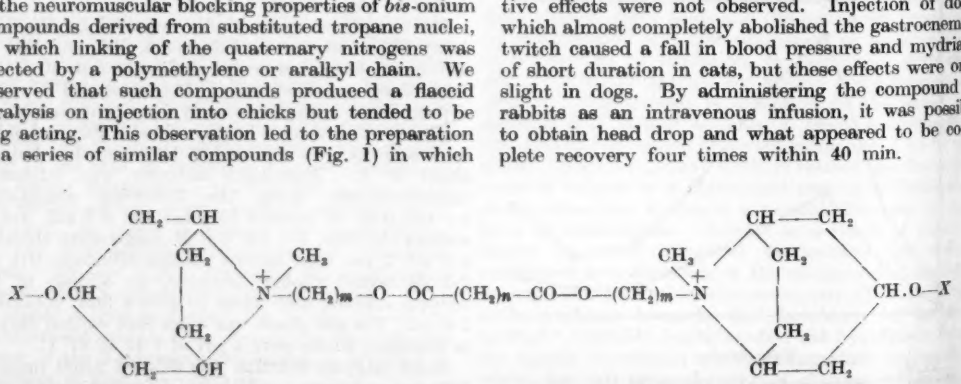
Table 1. Doses of *D.F.* 596 required to produce Paralysis in Different Species

Species	Test	Intravenous dose mgm./kgm. with limits of error ($P=0.05$)	
		D.F. 596	*d*-Tubocurarine chloride
Mouse	Dose causing 50 per cent of animals to fall from an almost vertical wire mesh screen within 1 min. of injection	0·23 (0·21–0·25)	0·041 (0·037–0·046)
Rat		0·40 (0·36–0·44)	
Rabbit	Dose causing head drop in 50 per cent of animals after a single rapid injection	0·16 (0·13–0·20)	
	Mean head-drop dose after slow infusion		0·18 (0·15–0·20)
Cat	Mean dose giving 50 per cent depression of gastrocnemius twitch	0·36 (0·28–0·46)	0·2* approx.
Dog		0·089 (0·061–0·117)	0·1 approx.

* Because of the cumulative action of *d*-tubocurarine this value was estimated from the initial dose injected into each animal.

Subsequent tests confirmed that several of the above substances combined the desirable short-acting property of suxamethonium with the competitive blocking action observed in other series of *bis*-tropinium compounds. Duration, potency and effects on blood pressure were found to be determined by the composition of the chain and the terminal acyl radicals. Short duration, low potency and marked hypotensive properties were favoured by high values of *n*, and greatest potency appeared to be associated with chains equivalent to 12 or 13 carbon atoms in length.

One of the most promising members of the series from the point of view of duration and potency was *D.F.* 596 (*X*, phenylacetyl; *n*, 4; *m*, 2). Doses of this compound required to produce paralysis after a single intravenous injection were determined in various species and are given in Table 1. By direct comparison it was found to be slightly more active than *d*-tubocurarine chloride in the dog and about half as potent in the cat. Duration of paralysis was comparable with that of suxamethonium and cumulative effects were not observed. Injection of doses which almost completely abolished the gastrocnemius twitch caused a fall in blood pressure and mydriasis of short duration in cats, but these effects were only slight in dogs. By administering the compound to rabbits as an intravenous infusion, it was possible to obtain head drop and what appeared to be complete recovery four times within 40 min.



X, Acyl radical; *m*, 2–3; *n*, 1–6.

Fig. 1

Neuromuscular block in cats and dogs due to *D.F.* 596 was antagonized by neostigmine, edrophonium, suxamethonium and decamethonium and augmented by ether and *d*-tubocurarine. During partial block the response to a tetanus was poorly maintained. The compound did not cause a contracture of chicken gastrocnemius or frog rectus abdominis muscle but antagonized contractures produced by suxamethonium on the former and by acetylcholine on the latter.

Rabbits anæsthetized with urethane and maintained by artificial ventilation tolerated large doses of the compound ; six animals which received a single intravenous injection of 100 mgm./kgm. were still alive 6 hr. later when ventilation was discontinued. In each case spontaneous respiration returned.

A full account of the work carried out on this and other closely related series will be published elsewhere. Patent applications are pending.

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Entropy and Synovial Pathology

Previous *in vitro* experiments on synovial metabolism have shown that the presence of rheumatoid disease in the synovial membrane resulted in marked metabolic changes[1]. The rate of uptake of oxygen was greatly altered by the presence of the disease, for example, normal synovium (of traumatic origin) $Qo_2(N)$ 1·0 up to $Qo_2(N)$ 35·0 in very active disease states. A crude relationship was found to exist between the macroscopic appearance of the pathological material and the rate of uptake of oxygen. As the change in uptake of oxygen was so marked in the rheumatoid synovia, we felt that some quantitative relationship might exist between the rate of uptake of oxygen and the state of the disease. The problem, therefore, was to obtain a quantitative method for expressing the pathological changes in the diseased synovium.

Rheumatoid arthritis is characterized locally by the occurrence of hypertrophy in the synovial and stromal layers, the appearance of round cell foci, plasma cells and to a lesser extent leucocytic infiltration in the subsynovium. The numbers of these various cell types vary greatly in different stages of the disease. Herdan[2] has shown that a quantity H, termed 'entropy' because of its formal similarity with the entropy of statistical mechanics, may be used for expressing changes in the pattern of serum proteins in pathological conditions and, more generally, could be used as a measure of pathological disorder. The entropy of the mixture, H, is calculated as the expression:

$$H = -\Sigma p_i \log_2 p_i$$

where p_i represents the proportion of a constituent. We have applied this expression to the synovial cytology of normal and pathological material. The cellular proportions were obtained by a standardized counting technique, the details of which will be reported in full elsewhere. The error of estimate was found by obtaining 25 separate estimates of H from a typical rheumatoid synovium. For this tissue the mean H was 1·989 and the standard error of the mean 0·023. H was calculated routinely from 10 separate estimates of the cellular counts in a variety of normal and rheumatoid synovia.

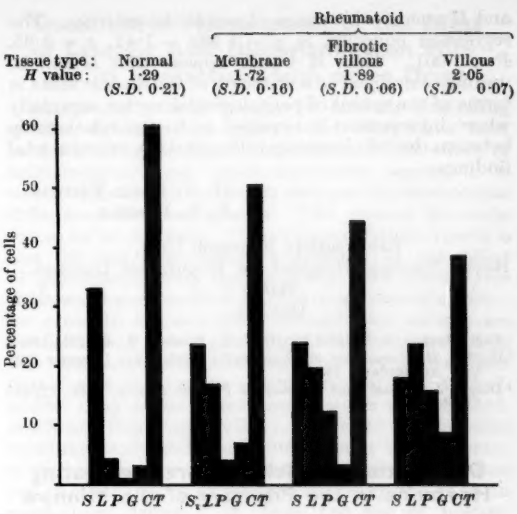

Fig. 1. The distribution of certain cell types in normal and rheumatoid synovia, together with their mean entropy values (*H*). *S*, Synovial cells; *L*, lymphocytes; *P*, plasma cells; *G*, granulocytes; *CT*, connective tissue cells; *S.D.*, standard deviation

Fig. 1 shows the average distribution of certain cell types in normal and rheumatoid synovial tissue. The rheumatoid synovia have been classified macroscopically as previously described by Dingle and Page Thomas[3]. Rheumatoid tissue shows a greater tendency to equidistribution of cell types, which is most marked in the villous material. The mean entropy values H were calculated for each of these distributions, and it may be seen that the value of H rises as the cellular content becomes more abnormal. Fig. 2 shows an application of this result to 19 different rheumatoid synovia of varying metabolic activity. There is a correlation between log $Qo_2(N)$

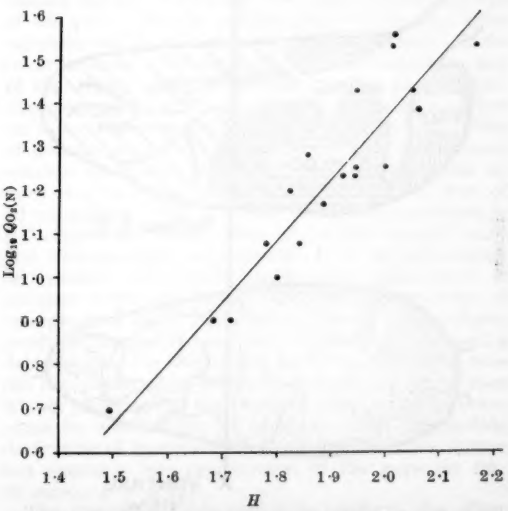

Fig. 2. The correlation of oxygen uptake with 'entropy' value for nineteen rheumatoid synovia

and H over a wide range of metabolic activity. The regression equation is $y = 1{\cdot}38x - 1{\cdot}41$, $r = 0{\cdot}95$, $P < 0{\cdot}001$. Thus it would appear that H can be usefully employed as a criterion of the disease state in terms of the extent of pathological disorder, especially where information is required as to the relationship between the cellular composition and the experimental findings.

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Distribution of Melanophore-aggregating Hormone in the Pituitary of the Minnow

The melanophore-aggregating hormone of the pituitary of *Gadus callarias*[1] and *Cyprinus carpio*[2] has been shown to be concentrated in the meta-adenohypophysis (pars intermedia). In *Parasilurus asotus* the hormone is concentrated in the meso-adenohypophysis (*Übergangsteil*)[3]. Spinal-sectioned minnows (*Phoxinus phoxinus*) are able to maintain the white background response after hypophysectomy provided some of the anterior part of the pituitary remains after the operation but not if the whole pituitary is removed[4].

In ventral view the minnow pituitary is seen to be divided into an anterior opaque region with few superficial blood vessels, corresponding roughly to the histological divisions of pro- and meso-adenohypophysis, and a less-opaque posterior region with considerable superficial vascularization corresponding roughly with the meta-adenohypophysis (Fig. 1).

Minnows (55–65 mm. long) taken from a stock maintained in a white tank were decapitated and the pituitaries exposed by removal of the floor of the mouth. With the aid of a small piece of razor blade attached to a glass rod, the pituitary was swiftly divided into two portions with a single cut along the line separating the two regions described above ($X - X'$ in Fig. 1). The two portions were removed and separately homogenized in 0·1 ml. of distilled water. The procedure, from decapitation to the separation of the two portions, was completed in 20–30 sec.

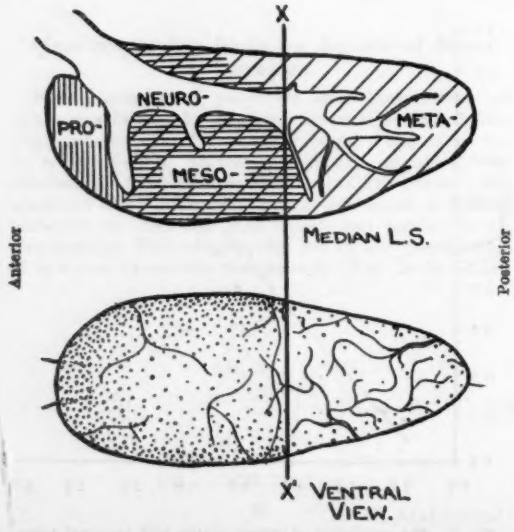

Fig. 1

Table 1

Response of *B* region melanophores of black-adapted minnows	Pituitary region	
	Anterior	Posterior
Change in melanophore index 1 hr. after injection	0·0	1·2
	0·0	2·6
	1·8	1·4
	0·4	2·8
	0·4	2·0
	1·4	3·0
	0·0	0·4
	1·2	1·0
	0·2	1·4
	2·0	2·6
	0·0	0·4
	2·0	1·8
	0·6	2·8
	0·0	1·4
	0·2	2·6
Mean	0·68	1·83
S.D.	0·777	0·878
	$P < 0{\cdot}01$	

The whole of the homogenate was injected into the body cavity of black-adapted minnows (60–65 mm. long). The melanophore index of the region *B* micromelanophores[5] of each individual was read immediately prior to injection and again 1 hr. after injection. The results are summarized in Table 1. In 10 out of 15 cases the posterior region of the pituitary showed greater melanophore-aggregating activity than the anterior region, while in five cases the responses were more or less equal.

Of particular interest is the fact that the melanophore-aggregating activity was detectable in both regions of the pituitary. In view of the short period of time elapsing between decapitation of the fish and separation of the two portions of the pituitary (30 sec.) it seems unlikely that appreciable diffusion of the hormone could have occurred. This suggests, in the light of Healey's observations[4], that the melanophore-aggregating hormone is produced in the anterior part of the pituitary and passed to the posterior part for storage.

Enami's observation[3] that the melanophore-aggregating hormone in *Parasilurus* has its origin in the nucleus lateralis tuberis of the hypothalamus suggests that a similar arrangement may occur in the minnow. Experiments aimed at detecting melanophore-aggregating activity in the minnow hypothalamus have been unsuccessful. While this does not preclude the possibility that the hormone is present in amounts too small to detect, it suggests that an alternative explanation may have to be sought to account for the condition in this species. The occurrence of large ganglion cells in the anterior part of the minnow neurohypophysis such as have been described in *Salmo* and *Gadus* and the apparent absence of a nucleus lateralis tuberis indicate a possible extra-hypothalamic source of neurosecretion. It is clear that further evidence is necessary before a final judgment can be made regarding the role of these cells in the production of the melanophore-aggregating hormone. Experiments aimed at obtaining such evidence are now in progress.

Acknowledgments are due to Dr. E. G. Healey for supervision and to the Department of Scientific and Industrial Research for a research scholarship.

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Dec. 11.

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Gibberellins and Nodulation

Recently, Fletcher, Alcorn and Raymond[1] presented evidence that gibberellins had no effect on the nodulation of white clover (*Trifolium repens*) grown either in aseptic agar or in soil. In concentrations from 1 to 1,000 p.p.m., gibberellic acid was also without effect on the growth of the nodule-forming organism *Rhizobium trifolii*. These combined results seemed to contradict a previous report of Thurber, Douglas and Galston[2], who had found a marked depressive effect of potassium gibberellate on nodulation in dwarf beans (*Phaseolus vulgaris*).

Although I have done no further work on this phenomenon since the original report, I have been in receipt of information from other workers in the field, who have corroborated and extended our findings. For example, Dr. P. W. Brian, of Imperial Chemical Industries, Ltd., has informed me that 10 and 100 p.p.m. sprays of gibberellic acid, applied daily or weekly, greatly depressed the number of nodules and the mean diameter of nodules of 14-day old plants of *P. vulgaris* var. Masterpiece grown in garden soil.

Similarly, Dr. N. P. Kefford, of the Commonwealth Scientific and Industrial Research Organization, Division of Plant Industry, Canberra, has found a depressive effect of gibberellic acid at 0·3 p.p.m. on nodule formation of lucerne (*Medicago sativa*, Hunter River) grown for 42 days on mineral agar, the acid in these experiments being added directly to the agar. In this case, the fewer nodules were each of larger volume than the controls, so that the nodule volume per plant was unaltered by treatment with gibberellic acid. Both Dr. Brian and Dr. Kefford plan to publish their results in detail.

In view of these results, involving independent demonstration of the same kind of phenomenon in three widely separated laboratories, it would seem that the original conclusion that gibberellins can inhibit nodulation is valid, and that some care is therefore required in the use of this product on legumes. It is also clear from the work of Fletcher *et al.* that not all legumes grown under all conditions will show this inhibitory effect of gibberellic acid. This difference in nodulation response is probably related to the already known fact that different genotypes of plants, presumably of varying endogenous gibberellin-levels, react quite differently to identical gibberellin applications.

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Quantitative Measurement of the Effect of Lysergic Acid Diethylamide on Mice and its Interactions with other Drugs

Although several species of animals (including spiders, fighting fish, pigeons and rats) have been used for the quantitative evaluation of the effect of hallucinogenic and psychotomimetic agents it is worth while to add to this list owing to the biochemical differences between species. The present favourite seems to be the rat[1]. This communication reports a test for the quantitative evaluation of the effect of psychotomimetic agents using mice chosen for their small size (useful if limited quantities of agent—for example, extracts from schizophrenic serum—are available) and ease of handling. A Latin square design was used employing four cages, each of 5 mice, and four modes of injection (saline, lysergic acid diethylamide, drug to be tested, and lysergic acid diethylamide and this drug together). The mice were injected subcutaneously and placed individually on the centre of a vertical pole at 1 min. intervals. The time (up to a maximum of 40 sec.) taken by the mice to reach lines drawn 1 in. from the top or bottom of the pole was then measured. Variability can be reduced by eliminating slow or erratic mice in preliminary tests. (The mice can also be trained to run down the pole under hunger drive. This procedure, however, introduces two new parameters—learning and hunger—which may be differentially affected by drugs.) Doses of lysergic acid diethylamide of 1 and 2 mgm./kgm. were used. The solutions were always freshly prepared and the effect tested of their interaction with adrenochrome, adrenolutin and the brom derivative of lysergic acid diethylamide. Fig. 1 shows the difference between the drug value and its matching saline value, with the latter corrected to a straight line at the level of the first saline value (maximum possible score = 200). All statistical work was done, however, on uncorrected results. As the results obtained were not normally distributed, all statistical evaluations were carried out using non-parametric methods (Wilcoxon's method for paired data).

It was found that lysergic acid diethylamide increases the time which the mice take to reach the end of the pole. This is maximum at 10–15 min. after injection and is still appreciable after 30 min. Bufotenin in doses up to 20 mgm./kgm. did not show any of this effect (nor any qualitative change). Adrenochrome in doses of 10 and 20 mgm./kgm. has no effect on mice demonstrable by this test or on the effect of lysergic acid diethylamide on mice. Adrenolutin inhibits the effect of lysergic acid diethylamide on mice but exerts no influence by itself in a dose of 20 mgm./kgm. (Fig. 1). This effect was confirmed in a further experiment using 40 trained hungry mice and 30 mgm./kgm. adrenolutin (P for the interaction of lysergic acid diethylamide and adrenolutin is between 0·02 and 0·05). The brom derivative of lysergic acid diethylamide in a dose of 1 mgm./kgm. produced a marked sedation of untrained mice and a delayed time for descending the pole. The same dose did not produce this effect in trained or hungry mice where, presumably, the sedative effect could be overcome by motivation or training. The morpholide derivative of lysergic acid diethylamide is less active but causes a late acceleration of the mice (at 30–60 min.: $P = 0{\cdot}02$).

The purpose of this test is to evaluate the effect of lysergic acid diethylamide and other psychoto-

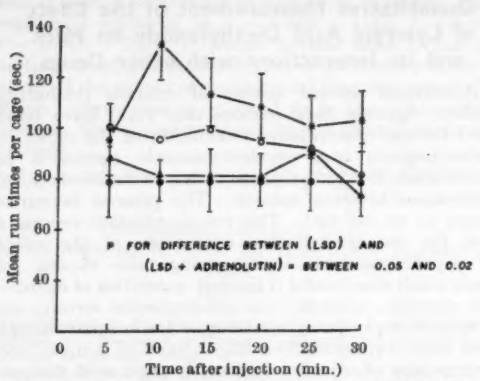

Fig. 1. Showing the effect of lysergic acid diethylamide (LSD), adrenolutin and their interaction. Cages *A–D*, each point representing 40 mice: ●, saline; ★, LSD (1 mgm. per kgm.); ▲, adrenolutin (20 mgm. per kgm.); ○, LSD + adrenolutin

mimetic agents quantitatively and to measure their interaction in mice. Inferences from these results to humans can only, of course, be made with caution. These experiments indicate that adrenochrome and adrenolutin (in the doses used) do not act on mice as lysergic acid diethylamide does and that they do not potentiate this action of lysergic acid diethylamide or vice versa (it has been claimed[2] that lysergic acid diethylamide in man potentiates the effect of adrenolutin). However, bufotenin, a known human hallucinogen, has no demonstrable effect either in mice even in large doses.

I am grateful to Dr. Harold E. Himwich and to Dr. Erminio Costa for their invaluable help and advice; to my technician, Mrs. Jennie Johnson, for her excellent work and to Drs. A. Hoffer, B. Melander of K.A.B.I., and S. Gimpel of Sandoz for generous gifts of adrenochrome, adrenolutin and lysergic acid and its brom derivative, respectively.

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Antibody Formation by Isolated Spleen Cells transferred to Recipients in Absence of Homotransplantation Reaction

It is generally agreed that the internal environment in new-born animals is not favourable for antibody formation to occur, as has been postulated by Dixon[1,2]. It has, however, been demonstrated in our laboratory[3–5] that new-born animals are more suitable recipients for transferred cells producing antibodies—during the period when they are not capable of their own active antibody synthesis[6]—than X-irradiated adult animals. We suppose that the homotransplantation reaction is the main factor limiting antibody formation by cells transferred to young animals[7]. Simonsen[8] has shown that spleen cells of adult hens are tolerated if transferred to chicken embryos three days before hatching. We assumed, therefore, that by using the chicken embryo as recipient it will be possible to obtain fully developed formation of antibodies to bacterial antigens and also a positive primary response to a protein antigen. According to Dixon's assumption, this should, on the other hand, lead to a further decrease in the intensity of antibody formation in embryos.

Normal White Leghorns weighing 1·5–2 kgm. were used as donors of spleen cells, which were isolated as described in a previous report[4]. Spleen cells mixed with antigen *in vitro* were transferred either by intraperitoneal route to chickens 2 days after hatching or into the chorioallantoic vein of 18-day-old chicken embryos. 6×10^7 cells were transferred to chickens and 5×10^7 cells to embryos. The number of cells was determined by counting in a Bürker's chamber. A heat-inactivated suspension of *Brucella suis* (in a ratio of two bacterial cells to one spleen cell) and bovine serum albumin (1 mgm. per embryo or chicken) were used. Cells were transferred simultaneously with antigen; to controls, animal cells only or antigens only were given. Blood for determination of antibody titres was taken at different time-intervals according to the antigen used. This was usually 10, 14, 20 and 28 days after transfer in the case of bovine serum albumin and 5, 7, 9, 12, 16 and 24 days after transfer when using *Brucella suis*. Antibodies were determined by agglutination of the suspension of *Brucella suis* or tanned sheep erythrocytes sensitized by bovine serum albumin. 73 per cent of chickens hatched from the embryos to which spleen cells had previously been transferred died within 15 days after transfer with typical symptoms of the runt disease. The decrease of blood hæmoglobin in chickens before death was even lower than 10 per cent. Symptoms of the runt disease served at the same time as indicator of a successful cell transfer.

The experiments were performed as follows. In the first group, cells with the *Brucella* antigen were transferred to two-day-old chickens and 18-day-old embryos. The antibody formation occurred in all the 20 transfers to chickens, with a maximum titre 1 : 128 (M = 1 : 32). Out of 17 transfers to embryos there was a positive antibody response in all experimental chickens, with a maximum titre 1 : 130,000 (M = 1 : 4,096). The transfer of cells only (13 embryos, 7 chickens) or antigens only (12 embryos, 9 chickens) was always negative during the critical period, that is, up to the fifteenth day of life. This group of experiments is illustrated in Fig. 1. In the second group of experiments bovine serum albumin was used as antigen under the same experimental conditions. In none of the transfers to

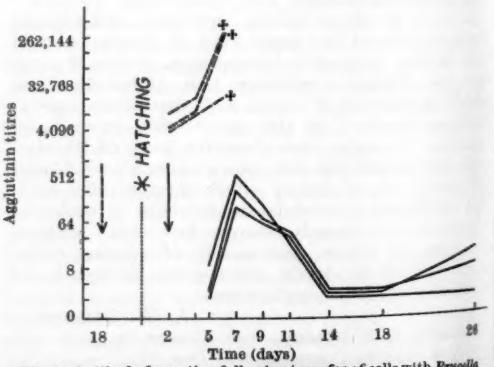

Fig. 1. Antibody formation following transfer of cells with *Brucella* antigen to embryos and chickens. Full line, transfer to 2-day-old chickens; interrupted line, transfer to 18-day-old embryos. A cross indicates that animals died with symptoms of the runt disease

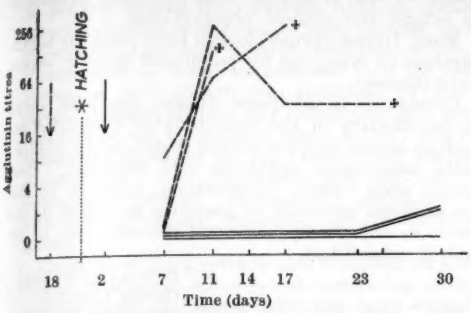

Fig. 2. Antibody formation following transfer of cells with protein antigen (bovine serum albumin) to embryos and chickens. Full line, transfer to 2-day-old chickens; interrupted line, transfer to 18-day-old embryos. A cross indicates that animals died with symptoms of the runt disease

chickens (26 transfers of cells with bovine serum albumin, 21 transfers of bovine serum albumin only and 18 transfers of cells only) was it possible to demonstrate any antibody formation. A positive response was, however, obtained in transfers to embryos during the critical period, that is, within 15 days; there were 21 positive responses out of 27 transfers performed, with a maximum titre 1 : 512 (M = 1 : 64). No antibody formation could be demonstrated in 18 control experiments in which cells only and in 27 control experiments in which bovine serum albumin only were transferred. This second group of experiments is illustrated in Fig. 2.

The results of our experiments primarily indicate that the immaturity of the recipient does not affect the response of the transferred cells, as has been postulated by Dixon and his co-workers, but that the limiting factor is the homotransplantation reaction. When the transplantation reaction is eliminated by using transfer to embryos, the transferred cells form antibodies in large titres. Using this experimental model in which the function of the transferred cells is not disturbed by the reaction of the recipient, we succeeded in obtaining antibody formation even to protein antigens, that is, in evoking a typical primary response.

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Presence of Antigen—a Factor determining the Duration of Antibody Formation by Transferred Cells

In experiments on antibody formation by isolated spleen cells after transfer to new-born rabbits[1] and newly hatched chicks and embryos[2] it has been found that the ability to form antibodies is limited in time, this being due to the reaction of the recipient

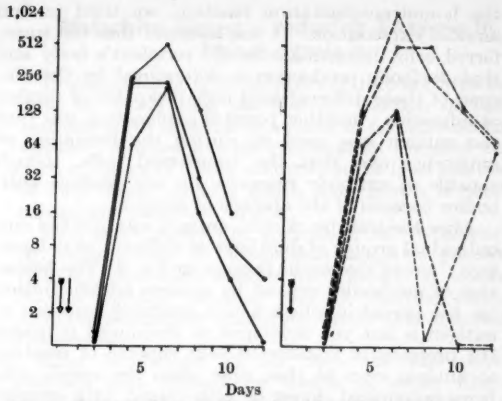

Fig. 1. Transfer of spleen cells intraperitoneally to one-day old ducklings. Left, 10^8 spleen cells (in 1 ml.) from normal adult donor mixed with antigen *Brucella suis in vitro*; right, 50 × 10^8 spleen cells (in 1 ml.) from adult donor immunized with three doses of antigen *B. suis*

to the transferred cells[3]. If spleen cells only were transferred to new-born rabbits and then antigen administered at different time intervals, it was demonstrated that only during the first 4 days after cell injection did the administered antigen regularly evoke antibody formation. Injection of antigen on the fifth day gave positive results only occasionally, and administration of antigen after the seventh day did not result in production of antibodies by transferred cells.

In further experiments one-day-old ducklings were used as recipients in order to find out whether the reaction of the recipient to the transferred cells is the only factor determining the period during which they are capable of producing antibodies. It is known[4] that at that period of life these animals are tolerant to transferred cells. Ducklings injected with bacterial antigen (*Brucella suis*) commence the formation of antibodies after the twelfth to fifteenth day of life.

Spleen cells from immunized adult duck or spleen cells from non-immunized donor mixed with antigen *in vitro* were transferred to one-day-old ducklings. In both cases (Fig. 1) the injected cells produced antibodies during a short period after transfer. Since the cells were injected into animals in which the decline in antibody formation cannot be ascribed to

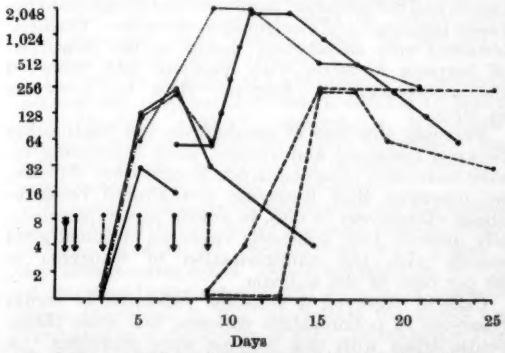

Fig. 2. Transfer of adult spleen cells only to one-day-old ducklings. Individual groups were injected with antigen *B. suis* immediately or 2, 4, 6 or 8 days after administration of cells

the homotransplantation reaction, we tried to find another explanation. It was assumed that the transferred cells differentiate in the recipient's body and that antibody production is determined by the life-span of those differentiated cells incapable of further proliferation; another possible explanation was that the antigen was used up during the formation of antibodies and that the transferred cells, though capable of antibody response, do not produce antibodies because of the absence of antigen.

After the transfer of cells, antigen was injected into individual groups of ducklings at different time-intervals; one of the results is given in Fig. 2. The formation of antibodies evoked by antigen administration (at the period in which active antibody response to antigen is not yet developed in ducklings) indicates the presence of transferred cells capable of reacting to antigen even at that time when the spleen cells from immunized donor or cells mixed with antigen *in vitro* and transferred to ducklings cease to produce antibodies (Fig. 1). The decrease in antibody formation by transferred cells may be explained by the absence of antigen.

These findings show that transfers to non-reactive recipients may be used for determining the importance of the presence of antigen for antibody formation.

Further details will be published elsewhere[5].

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Antiviral Activity of Lysozyme

The biological significance of lysozyme is not yet fully established. Its properties suggest that it has a role in immunism against bacterial infections. Lysozyme also seems to show antiviral activity. Previous observations support this possibility.

Macfarlane Burnet[1] observed that nasal mucus inactivates poliomyelitis virus of any type *in vitro*; on the other hand, however, pure lysozyme did not. Caselli and Schumacher[2] demonstrated antagonism between lysozyme and electronegative viruses. Orzalesi[3] obtained very satisfactory results in the treatment of herpetic keratitis with lysozyme and observed the inactivation of herpetic virus by lysozyme *in vitro*.

Pursuing this line of research on the relationship between lysozyme and viruses, some interesting results have been obtained in our laboratories. *In vitro*, we observed that lysozyme precipitated bacteriophage viruses and *in vivo*, in guinea pigs experimentally infected with aphthosis virus, we obtained good results with the administration of lysozyme in 80 per cent of the animals.

Callerio observed a constant reduction of serum lysozyme in poliomyelitis patients, but some therapeutic trials with this enzyme were confusing. A communication from A. D. Ronchese of Nice, stating that he has obtained recovery in four cases of herpes zoster by oral treatment with lysozyme, induced us to extend our clinical observations[4].

Many Italian dermatologists have tried the administration of lysozyme by parenteral route in several virus diseases.

Lysozyme, in adequate dosage, has been shown to be effective in the treatment of viral infections such as herpes simplex, herpes zoster, warts, condylomata acuminata, aphthosis and vaccinia. These results need further confirmation, however, so that the antiviral spectrum of lysozyme as well as its real value in the therapy of viral diseases may be definitely established.

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BACTERIOLOGY

Decomposition of Anionic Surface-Active Agents by Soil Bacteria

In a review of water pollution problems created by the persistence of anionic surface-active compounds in sewage and sewage effluents, Southgate[1] has pointed out that sodium alkyl sulphates are more susceptible to biological degradation than the alkyl benzene sulphonates which are active constituents of some domestic detergents. This resistance of the alkyl benzene sulphonates of commerce to biological oxidation has been attributed to the branched carbon atom chains of their alkyl groups. On the other hand, the alkyl sulphates in common use have, fortuitously, alkyl groups with straighter carbon chains more readily oxidized by micro-organisms[1]. Although some bacteria attacking anionic compounds have been reported[2], there is very little published information on bacteria responsible for breaking down even the more easily decomposable compounds.

This communication records the isolation of a bacterium able to use both primary and secondary alkyl sulphates as carbon sources. This organism developed from a sample of allotment soil which had been incubated at 25° C. for two weeks with water containing a trace of 'Teepol 530', a secondary alkyl sulphate. After further cultivation in a buffered mineral salt solution ($(NH_4)_2SO_4$, 0·5 gm.; K_2HPO_4, 6·5 gm.; KH_2PO_4, 3·5 gm.; $CaCl_2$, 0·05 gm.; $MgSO_4.7H_2O$, 0·05 gm.; NaCl, 1·0 gm.; distilled water, 1 litre; *p*H 7·0) with 0·1 ml. 'Teepol' per litre, the organism was isolated from plates of the same medium solidified with 1·5 per cent agar.

Cells of this isolate are aerobic, Gram-negative rods, 0·6–0·7μ × 0·6–2·2μ, with polar flagellation. Only in very young cultures are all the cells vigorously motile. On nutrient agar prepared from fresh ox heart extract and peptone, a trace of greenish fluorescent pigment appeared in the medium; but little or no such pigment formed in media made from commercial meat or yeast extracts. Acid but

no gas was formed from glucose, fructose, mannose, galactose, xylose, arabinose, sucrose, maltose, lactose, glycerol and mannitol. Starch, cellulose, salicin and *Ricinus* seed oil were not attacked. In the test of Shewan *et al.*[4], growth was inhibited by streptomycin, chloramphenicol and terramycin but not by penicillin or the vibriostatic agent 0/129. For these reasons the organism has been referred to the genus *Pseudomonas*; but the species has not yet been identified or named. It does not correspond well with any previously described soil or freshwater species.

The effect of the growth of this organism on surface tension in mineral salt solution containing different concentrations of 'Teepol 530' has been examined (Table 1). Surface tension measurements were made with a du Noüy tensiometer at 20° C.

Table 1. Changes in Surface Tension of Media containing Different Concentrations of 'Teepol 530' during Two Days of Incubation

Conc. 'Teepol' ml./l. medium	Surface tension (dynes/cm.)					Increase (per cent)
	Initial		After 2 days		Increase	
	Duplicate samples	Mean	Duplicate samples	Mean		
0·1	36·2 35·3	35·8	68·3 68·1	68·2	32·4	90·5
0·2	35·7 35·2	35·5	66·7 67·3	67·0	31·5	88·7
0·5	32·9 32·4	32·7	53·4 53·2	53·3	20·6	63·0
1·0	31·5 31·4	31·5	42·8 41·6	42·2	10·7	34·0
2·0	31·3 31·3	31·3	33·2 33·0	33·1	1·8	5·8

After two days cultures originally containing 0·5 ml./l. 'Teepol' or less had almost no tendency to foam on shaking. Foam stability was also greatly decreased in cultures with higher concentrations of 'Teepol' even though increases in surface tension had been only slight during the period of test. In a second experiment in which 500 ml. portions of the same basal medium containing 2 ml. 'Teepol' per litre were incubated for 16 days, foam was also very unstable after 3 days but did not become noticeably more unstable thereafter. Though growth, as judged by measurements of turbidity, ceased between the fourth and sixth days, surface tension rose steadily from 31·1 dynes/cm. at the start of the experiment to a final, but still low, value of 47·0 dynes/cm. on the sixteenth day. The bacterium could grow well in media containing, as sole carbon sources, primary sodium alkyl sulphates with alkyl groups of 10–18 carbon atoms. Also utilized were all the five 'Empilan' alkylolamide detergent additives which were tested: these were Types *AL*, *CM*, *LDE*, *LP*2 and 303 (Marchon Products, Ltd.). However, tetrapropylene benzene sulphonate, an active constituent of some commercial detergents, was not attacked. Indeed, though many soil micro-organisms were observed to tolerate the presence of this persistent compound, none capable of utilizing it could be isolated.

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Malachite Green - reducing Enzyme in *Mycobacteria*

In experiments with the lipids of different *Mycobacteria* we found that the acetone solution of lipids becomes green in colour as a result of certain oxidizing agents. A more precise examination revealed that such a change in colour occurred in the lipid solutions of only those bacteria which were grown in media containing malachite green.

Four saprophytic (*M. butyricum*, *M. friburgensis*, *M. rabinowitsch*, *M. smegmatis*) and two parasitic (*H37Rv.*, Ravenel) strains were grown in normal Sauton culture medium and in Sauton culture medium containing malachite green (10 μgm./ml.) respectively.

After incubation for six days the saprophytic cultures were filtered by means of paper filters, washed five times with distilled water, and dried at 37° C. over calcium chloride. 250 mgm. dry weight of the bacteria was suspended in 2·5 ml. acetone and left at room temperature for 10 min. Then 250 mgm. of lead dioxide was added, and the tubes were shaken, and centrifuged. The supernatant contained lipids or, in the case of a medium containing malachite green, it contained this dye. The parasitic strains were incubated for 50 days, sterilized in the autoclave, and then treated in the same manner as the saprophytes. In order to identify the dye and to measure its quantity, the absorption curves of the solutions were determined with the use of a Beckman spectrophotometer at 340–700 mμ wave-lengths.

It was found that the maximal absorption values for the solutions of the bacteria grown in a medium containing malachite green were at 420 and 630 mμ. In contrast, the solutions of the bacteria grown in normal Sauton medium showed no absorption at the wave-lengths studied. The maximal absorption values for the acetone solutions (2 μgm. per ml.) of the malachite green oxalate used were found to be at 430 and 630 mμ. The relative intensity of the absorptional maximal values was $630 > 430$ or in the case of bacterial lipid solutions $630 > 420$.

On the basis of the results of spectrophotometric examination it seems likely that malachite green is reduced by the growing bacteria, and the leuco-compound remains absorbed in the bacterial bodies. By means of lipolysing agents, it can be extracted together with the bacterial lipids, and then it becomes again a coloured compound after oxidation. The amount of the dye reduced is great, as shown by the fact that ten times as much malachite green (20 μgm./ml.) as the quantity used in normal media (for example, Sula medium) can be reduced by growing mycobacterial strains.

In order to establish the *p*H optimal for reduction, acetone-dry preparations made according to Edson's and Hunter's method[1], saprophytic *Mycobacteria* grown in Sauton medium for 5 days, were used. Such preparations can be stored for indefinite periods in refrigerators without loss of potency.

In order to measure the amount of the dye reduced at various *p*H-levels under the same periods of time, 10-mgm. acetone-dry preparations were placed in dry Wassermann tubes. After the addition of 1 ml. of universal buffer solution and 10 μgm. of malachite green (dissolved in 0·2 ml. water) the tubes were incubated in a water-bath of 37° C. for 30 min. Then, the tubes containing the suspensions were shaken in the presence of 2 ml. of acetoacetic ester for 5 min. and centrifuged. The upper aqueous layer was

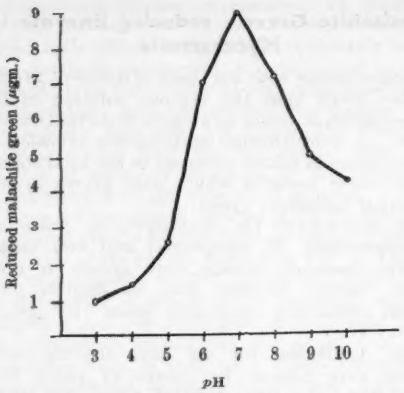

Fig. 1. Effect of *p*H on the reduction of malachite green by acetone-dry powder of *M. friburgensis*. Incubation, 30 min. at 37° C., in universal buffer solution

removed. To the acetoacetic ester malachite green solution 100 mgm. of anhydrous magnesium sulphate was added, the tubes were shaken, centrifuged, and the pure solution obtained was examined with a spectrophotometer at 630 mμ to determine the amount of malachite green.

The *p*H optimal for reduction was found to be 7·0 (Fig. 1).

Using *p*H 7·0 buffer solution the preparations were entirely inactivated by incubation at 60° C. for 30 min.

In addition, inactivation of the preparations could be obtained by *p*-chlormercuric benzoic acid, monoiodoacetic acid and hydrogen peroxide. Cystein or glutathione was found to reactivate the inactivated preparations.

The enzyme responsible for the reaction could not be extracted from the bacteria by the usual methods. It is suggested, therefore, that this enzyme is not identical with the reported reducing enzymes of the *Mycobacteria*[2–5].

Further observations will be reported in due course.

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Selection of Bacterial Mutants of Increased Sensitivity to 'Aminopterin'

Some understanding of the cellular responses which modify the effectiveness of growth-inhibitors can be gained by the study of closely related populations of microbial or mammalian cells differing in degree of sensitivity to a drug. Microbial cell lines resistant to antibiotics and antimetabolites can be developed readily by the selection of cells capable of surviving in the presence of increasing concentrations of such drugs[1]. Similar selection of drug-resistant neoplastic cells has been accomplished both *in vivo*[2] and *in vitro*[3]. Occasionally the development of resistance to one drug is accompanied by changes which confer an increased sensitivity to a different agent, a finding applicable to both microbial[4] and neoplastic cells[3,5]. The physiological mechanisms and metabolic systems associated with any increased effectiveness of drugs are of vital concern, but have received little attention because of the technical difficulty of directing the selection towards an increased, rather than decreased, responsiveness to a drug if that drug is used as the selecting agent. This communication concerns the reproducible selection in the absence of the drug of bacterial mutants of increased sensitivity to a folic acid antagonist ('Aminopterin').

Pediococcus cerevisiae, strain 8081, has been widely used for the assay of reduced derivatives of pteroylglutamic acid (folic acid) such as 5-formyl-tetrahydropteroylglutamic acid, which have folinic acid activity[6]. This organism can grow, however, in the absence of folinic acid if very high concentrations of pteroylglutamic acid are provided in the medium[7]. Pteroylglutamic acid was used as a selecting agent for strains which could grow well in media supplying progressively smaller amounts of this form of the vitamin. Over the course of eleven transfers, the concentration of pteroylglutamic acid necessary for growth was reduced from 2,000 mμgm. to 10 mμgm. per ml. of medium. The response of the selected strain (8081/*S*) to 5-formyl-tetrahydro-pteroylglutamic acid was identical to that of the parent organism (Table 1). Thus, it was possible to compare the sensitivity of these strains to 'Aminopterin' in the absence of the selecting agent by using a medium containing 5-formyl-tetrahydro-pteroylglutamic acid. The selection of strains capable of growing in medium containing 10 mμgm. of pteroylglutamic acid per ml. was repeated twice. In each case these cell lines were found to be 60–100 times more sensitive to 'Aminopterin' than the parent strain (Table 1). The characteristics of increased sensitivity to 'Aminopterin' and ability to grow promptly at low concentrations of pteroyl-

Table 1. Comparison of the Response of *Pediococcus cerevisiae* 8081 and a Selected Mutant (8081/*S*) to Folic Acid, Folinic Acid and 'Aminopterin'

Compounds tested		*Pediococcus cerevisiae* Parent strain 8081	Mutant strain 8081/*S*
Liquid medium*		mμgm. per ml. of liquid medium	
Pteroylglutamic acid (folic acid)—amount required for half-maximal growth		>1,000	3·0
5-Formyl-tetrahydro-pteroylglutamic acid (folinic acid)—amount required for half-maximal growth		0·4	0·4
4-Amino-pteroylglutamic acid ('Aminopterin')—amount required for inhibition of growth by 50 per cent†		160	2·5
Solid medium‡	mμgm. per pad	Diameter of zone (mm.)	
Pteroylglutamic acid (zone of growth)	10	No zone	16
	100	,,	24
	1,000	,,	31
4-Amino-pteroylglutamic acid (zone of inhibition)†	10	,,	19
	100	,,	26
	1,000	17	30

* The compounds were added to a medium used for the microbial assay of folinic acid activity (refs. 6 and 7). The concentration required for 50 per cent growth was determined from a graph of the complete curves for growth and inhibition.

† The inhibition of growth by 'Aminopterin' was measured in liquid and solid medium which contained 1·0 mμgm. per ml. of the active isomer of 5-formyl-tetrahydro-pteroylglutamic acid.

‡ The same medium with the addition of 1 per cent agar was seeded with each organism and poured into flat 'Pyrex' dishes. Solutions of the compounds were pipetted on to filter paper disks of ½ in. diameter which were placed on the surface of the solid medium. Each figure represents the average diameter of two zones, each measured along two 90° axes.

glutamic acid were retained after fifteen passages in the absence of the selecting agent.

In this case, in which the metabolite, pteroylglutamic acid, exerted a selective pressure in the direction of its more effective utilization, the selection was consistently accompanied by an increased sensitivity to a corresponding antimetabolite, 4-amino-pteroylglutamic acid. The ability to use a metabolite as a selecting agent apparently requires that the organism should have the potentiality of increasing its efficiency for the utilization of the metabolite. In any instance in which such a selection can be accomplished, this approach appears to be useful for the study of an altered response to corresponding antimetabolites. The requirement of cultures of leukæmic cells for 5,000-fold higher concentrations of folic acid than folinic acid[8] indicates that similar manipulation of the sensitivity of such neoplastic cells may be feasible. An equivalent increase in the sensitivity of strain 8081/*S* has been observed with respect to both 4-amino-pteroylglutamic acid and 4-amino-10-methylpteroylglutamic acid ('Methotrexate'); related compounds can be compared with respect to cross-sensitivity. Also, it will be of interest to study any characteristics which can be associated with the increased sensitivity of strain 8081/*S* to 'Aminopterin' in relation to the development of resistance by cells of this strain selected by this drug.

The mutant of *Pediococcus cerevisiae* (strain 8081/*S*) selected by pteroylglutamic acid now resembles *S. faecalis* and *L. casei* with respect to their characteristic growth requirement for either folic acid or folinic acid and their high degree of sensitivity to 'Aminopterin' and 'Methotrexate'. The nutritional selective pressure used in these studies may be a counterpart of the natural selection which occurred at some time during the evolutionary development of organisms such as *S. faecalis* and *L. casei*.

This investigation was supported in part by a research grant (*CY* 2906) from the National Cancer Institute of the U.S. Public Health Service. The capable assistance of Mr. Robert J. Leonard is gratefully acknowledged.

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AGRICULTURAL SCIENCE

Varietal Resistance to Spray Damage in Barley

IN experiments designed to control insect pests in the cereal nursery at the Welsh Plant Breeding Station it was noticed that there was considerable damage on barley plants after spraying with a proprietary insecticide containing DDT, which had been applied according to the manufacturers' instructions for field spraying. Certain plants suffered severe chlorosis; the sprayed leaves turned yellow and failed to recover, while succeeding leaves were green and appeared to be unharmed although productivity was severely reduced. Spraying at the early seedling stage and under unfavourable environmental conditions caused wilting and even death of the plant.

R *R* *S* *S* *R* *R* *S* *S*

Fig. 1. Typical reaction of four barley varieties to spray damage. *R*, resistant; *S*, susceptible

Further investigation in both greenhouse and field nursery showed that the damage was confined to certain varieties. Fig. 1 shows the clear-cut reactions of typical resistant and susceptible varieties under greenhouse conditions. Twenty-six commercial varieties of barley are classified in Table 1 according to a distinct reaction of resistance or susceptibility to spray damage.

Table 1. REACTION OF SOME BARLEY VARIETIES TO SPRAY DAMAGE

Resistant	Resistant	Susceptible	Susceptible
Balder	Maythorpe	*Atlas	Praecox
Carlsberg II	Prefect	Domen	Piroline
Earl	Proctor	Freja	Primus
*Goldberg	Provost	Frisia	Rika
*Gull	Spratt Archer	*Haidd Hen Enlli	Vinesco
Ingrid	Ymer	*Hen Gymro	Wisa
Kenia		Herta	

* 'Land' variety or selection

Preliminary evidence that this reaction is genetically controlled was obtained by studying the pedigree of the above varieties. For example, it can be seen from Table 1 that Provost (resistant) was derived from a cross between Kenia and Spratt Archer, both of which, it will be noted, are resistant, while Prefect is a resistant segregate from the susceptible form Praecox and the resistant Spratt Archer. Confirmatory evidence of the genetic mechanism involved was obtained from the reaction of F_1 and F_2 plants from crosses of resistant and susceptible parent plants. Progeny from resistant × resistant crosses were all resistant to spray damage, while susceptible × susceptible crosses gave only susceptible progenies.

Table 2. Reaction of F_1 Plants and F_2 Segregates from Resistant × Susceptible Crosses

Parents	Generation	Expected or observed	No. of plants	
			Resistant	Susceptible
Resistant × Susceptible	F_1	Observed	—	72
	F_2	Observed	83	203
		Expected (3 : 1 ratio)	71·5	214·5

$\chi^2 = 2{\cdot}25$. $P = 0{\cdot}50$–$0{\cdot}10$.

Inheritance studies on resistant × susceptible crosses gave the segregation in Table 2.

All the available evidence, therefore, strongly indicates that varietal differences are controlled by a single major gene with susceptibility dominant to resistance.

Reference to Table 1 emphasizes that the alleles are randomly distributed among the commercial varieties of barley; thus there is no suggestion that this gene has had any selective influence in previous plant-breeding programmes. Furthermore, studies to date have not revealed any gross morphological features associated with this reaction. It is interesting to note the reaction of the five 'land' varieties and their derivatives; for example, Gull, the 'land' variety from Sweden, is resistant, while recently bred varieties from the same country, namely, Herta and Rika, are susceptible. Atlas, a selection from Coast which is believed to have been introduced into North America by the Spanish settlers, and Hen Gymro from Wales, are both susceptible. Thus there does not seem to have been any advantage or disadvantage associated with this gene during the evolution of the cultivated barleys. Since the use of insecticides on agricultural crops is of recent origin, it follows that this factor, which does not appear to have any other expression, has not hitherto been selected by plant breeders.

A knowledge of varietal reaction of this nature is important to research workers developing new insecticides as well as plant breeders. It will be a simple matter from the plant breeding point of view to avoid developing new varieties of barley which are susceptible to this damage, on account of the fairly large number of well-adapted resistant types already available. Further work is in progress to determine the nature of the chemical constituent responsible for the damage and the full genetic and physiological action involved.

Fuller details of this investigation will be published elsewhere.

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Rumination in Sheep caused by Injection of Adrenaline

The injection of adrenaline into sheep anæsthetized with chloralose causes a rapid secretion of parotid saliva[1]. This is a reflex effect and appears to be due largely to stimulation of receptors in the forestomach. Parotid secretion is also increased by mechanical stimulation of the forestomach and in conscious sheep this stimulation may cause rumination[2]. Thus it seemed of interest to find whether adrenaline would cause the conscious sheep to ruminate, and observations on this subject are summarized here.

Six sheep trained for the experiments were each fitted with a rumen cannula and a cannula in one parotid duct. Contractions of the reticulum were recorded with a water manometer connected to a balloon placed in the organ and the flow of parotid saliva was recorded with a Throp drop counter. Adrenaline ('Adrenalin'; Parke, Davis) was injected during 5 sec. through a catheter inserted into a jugular vein.

A period of rumination followed adrenaline injection in all the sheep. An example is shown in Fig. 1, in which the onset of rumination is signalled by a triphasic contraction of the reticulum of lower amplitude than previous contractions and is accompanied by an increase in parotid secretion.

The threshold dose of adrenaline was 0·2–0·7 μgm./kgm. body-weight and there was a delay of 40–155 sec. between the start of the injection and the first regurgitation. Rumination was preceded by a number of changes, including alert movements of the head, sneezing, belching, urination or an increase in parotid secretion. Removal of the rumen contents and of the reticulum balloon made little or no difference to the threshold dose. In such sheep 'rumination' consisted of triphasic reticulum contractions and regurgitation of fluid. Larger doses of adrenaline (2–20 μgm./kgm.) caused rumination in most trials, although the initial triphasic reticulum contractions were often depressed. The latency of the response varied from 24 to 137 sec. Slow injection of adrenaline in doses of 1–20 μgm./kgm. during 2 min. failed to cause rumination. Noradrenaline ('Levophed'; Bayer) caused rumination in 3 of the 4 sheep tested at threshold doses of 1·5, 2·5 and 5·0 μgm. noradrenaline base/kgm. Injections of saline alone had no effect.

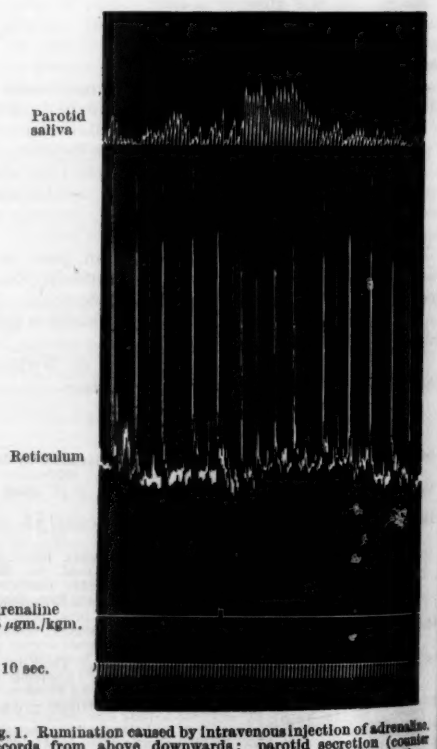

Fig. 1. Rumination caused by intravenous injection of adrenaline. Records from above downwards: parotid secretion (counter returned to base-line at 10-sec. intervals), reticulum contractions, signal, 10-sec. time marker

It is possible that adrenaline causes rumination by the same reflex mechanism that is concerned in the stimulation of parotid secretion in anæsthetized sheep. It is unlikely that the adrenaline acts on forestomach mechanoreceptors indirectly by causing muscular contraction, for no abnormal contraction was recorded from the reticulum and its action on the stomach of conscious sheep is known to be inhibitory[3]. The threshold dose of adrenaline, 0·2–0·7 μgm./kgm., corresponds to mean plasma adrenaline concentrations of 4–14 μgm./l., assuming 50 ml. plasma/kgm. body-weight. Although these concentrations are similar to those of 2·44–12·6 μgm./l. found by Weil-Malherbe and Bone[4] for bovine plasma, the blood analysed by these authors was collected at slaughter when adrenaline-levels might well be elevated abnormally. Moreover, to cause rumination the adrenaline had to be injected rapidly, so that the actual plasma concentration will transiently have exceeded the mean plasma concentration. It must be emphasized, therefore, that the present observations do not indicate that adrenaline release plays a part in the initiation of rumination in the normal animal. On the other hand, Loewenstein[5] has shown that both the application of adrenaline or noradrenaline to frog skin and stimulation of the sympathetic innervation cause activity in cutaneous touch receptors, and suggested that sensitization of such receptors through the sympathetic nervous system might normally occur in intact animals. The receptors of the sheep's forestomach may also be sensitized in this way.

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Inducing Chlorophyll Formation in Albino Citrus Seedlings

Albino seedlings, that is, seedlings lacking chlorophyll, are observed in varying degrees in citrus seed beds according to variety. In sweet lime 30 per cent or more of the young seedlings may be albino. This lack of chlorophyll is attributed by some botanists to infection with an unknown disease. Treating citrus seeds before planting with mercuric disinfectants such as 'Ceresan'[1] and 'Agrosan'[2] resulted in the production of seedlings which with the former were nearly all and the latter all green. In this study albino seedlings were grafted on to green seedlings to see whether chlorophyll formation would be blocked in the latter as a result of possible transmission of the disease which is suspected to cause albinism or whether chlorophyll formation could be induced in albino seedlings.

Sweet lime seeds were planted in a mixture of 1 part sand to 3 parts loam in an incubator at 28–30° C. and 80–90 per cent humidity. Because the sweet lime is polyembryonic, more than one seedling were produced per seed. In many instances both albino and green seedlings were produced from the same seed, and thus were very close to each other, making grafting in these young seedlings possible. Grafting was done by the approach method in which a small slice of stem of both the albino and the green seedlings were cut and the cut surfaces brought together and tied until they united. The cuts were made as high as possible to leave a few buds on the stem of each seedling. Grafting was done as soon as the plants were about 5 cm. high. Too long a delay must be avoided, for the albino seedlings usually die after using up the food reserve in the embryos from which they develop.

Out of 30 grafts 11 succeeded. The tops of the albino seedlings above the grafting union died. None of the green seedlings in these successful grafts showed any chlorophyll irregularities as a result of grafting an albino seedling (which is supposedly diseased) on it.

A year later, leaves of the originally green seedlings were still green and the stems of such seedlings at the grafting union-level was about 1 cm. in diameter. The stems of the albino seedlings reached about the same diameter but no shoots grew on them, although they had a few buds on each. These buds were forced to grow by ringing the stems of the originally green seedlings immediately above the grafting union. All shoots produced in this way had only green leaves and seemed normal. These shoots remained green after separation of the two seedlings from each other.

These findings indicate that the causal factor of albinism was not transmitted across the grafting union, or if transmitted was unable to induce albinism in the originally green seedlings. The results also show that the effect of this causal factor is temporary and limited to the early stages of seedling growth. Cutting off the top of the originally green seedlings to the grafting union or separation of the originally albino from the originally green seedling (top and root) did not cause any disturbance in chlorophyll formation in the green shoots obtained from originally albino seedlings. This result seems to contradict the view that albinism is due to recessive genes, as was claimed for the Szinkom mandarin[3].

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Antigenic Stimulus of Exsheathing Fluid in Self-Cure of Sheep infested with *Haemonchus contortus*

It has been reported that the second ecdysis of *Ascaris lumbricoides* is probably important in the stimulation of protective immunity in guinea pigs[1–2]. Up to 4 days after the administration of ova, developing larvæ appear to be of little importance in stimulating immunity and are themselves unaffected by immune processes. Using the Forssman antibody as a natural marker, it was demonstrated that a large release of antibody does not occur until 4–5 days after the administration of ova[3]. This period coincides with the second ecdysis, and it was suggested that this process is important in stimulating immunity by the liberation of antigens.

Two stages are involved in the second ecdysis of nematode larvæ in sheep[4]. Larvæ are activated by a dialysable factor or factors in the alimentary tract

and then secrete exsheathing fluid from a region near the base of the œsophagus. Exsheathing fluid acts on a circumscribed region of the cuticle which eventually fractures and enables the larva to escape. Exsheathing fluid was collected as a dilute solution[5] which was found to contain other antigenic substances also released by the larvæ at the time of the second ecdysis.

The self-cure reaction is produced in hypersensitive infested sheep by the intake of infective larvæ. The reaction is accompanied by a rise in circulating antibodies and a transitory rise in blood histamine[6].

The serological reaction which occurs at the time of self-cure has now been examined by the Ouchterlony agar-diffusion precipitin technique. It was found that four lines developed when heated *Haemonchus contortus* antigen[7] was tested with a serum obtained when self-cure took place after the administration of *H. contortus* infective larvæ to an infested sheep. The antigenic components responsible for the main reactions were identified by the cross-reactions which occurred between the serum, the heated antigen, exsheathing fluid solution from *H. contortus* infective larvæ and metabolic products. The metabolic products were collected by harvesting a saline solution in which exsheathed *H. contortus* infective larvæ had been kept with added antibiotics for 24 hr. at room temperature. The line which appeared closest to the antigen well was produced by tissue antigens, the second line also by tissue antigens together with a component due to exsheathing fluid solution, the third line mainly by exsheathing fluid solution but partly by metabolic products, and the fourth line, closest to the serum well, was produced primarily by metabolic products. It is not surprising that there was some overlapping between these lines, because exsheathing fluid solution was found to contain a number of antigenic substances, some of which are also present in metabolic products.

The agar-diffusion precipitin reactions developed with serum collected within a week of the administration of larvæ, and the lines produced by metabolic products and particularly by exsheathing fluid solution were the most pronounced. By slaughtering infested sheep at intervals after the administration of infective larvæ it was found that, at the time of the self-cure reaction, when much of the existing adult *H. contortus* infestation was located in the small intestine and was in a state of disintegration, fourth-stage larvæ of varied size as well as third-stage larvæ were present in the abomasum. It seems probable, therefore, that the self-cure reaction is initiated by an antigenic stimulus arising from the third ecdysis. Although there is as yet no evidence that the third ecdysis produces exsheathing fluid, the serological evidence indicated that similar antigens were released as in the second ecdysis.

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BIOLOGY

Occurrence of *Pyrosoma* on the Sea-Floor 160 Metres Deep

Pyrosoma species are commonly encountered as surface or midwater planktonic organisms. Among photographs taken of the sea-floor of Cook Strait, New Zealand, two exposures show what are undoubtedly tunicates, almost certainly *Pyrosoma atlanticum atlanticum* Peron, resting on or swimming just above the bottom at a depth of 160–170 m.

The depth is in itself not unusual—Thompson[1] reports finding this species off Australia in greatest numbers between 250 and 500 m.—but we are not aware of previous records of *Pyrosoma* so close to the bottom. It may be that our records indicate no more than a normal range of depth distribution. On the other hand, since they were made at 1022 and 1505 hr. they may indicate a daytime preference for deeper water; Thompson does not indicate the times at which his observations were made. It is possible that the animals are actively seeking the bottom to avoid other unfavourable surface conditions.

The shadows cast by a camera flash (New Zealand Oceanographic Institute Station *C*.122, 18.5.58; 162 m.; lat. 41° 19′ 04″ S.; long. 174° 32′ 36″ E.) show that the *Pyrosoma* are within inches of the bottom, and some are certainly resting on it. They are firm and regular in shape, indicating that they are not dead and decomposing. Shadows and blurred shapes in another photograph (New Zealand Oceanographic Institute Station, *C*.119, 17.5.58, depth 169 m.; lat. 41° 18′ 45″ S.; long. 174° 32′ 30″ E.) indicate specimens actively swimming just above the sea-floor.

At this time of the year (May 1958), *Pyrosoma* were extremely common in the Cook Strait region. Mr. N. M. Ridgway, of this Institute, noted that colonies up to 15 in. long were frequently seen swimming past the ship at night during May 15–19, and were occasionally entangled in the wires used for current measurements. On May 16, Mr. F. C. Abernethy, engineer of the trawler *Thomas Currel*, recorded large numbers off Cape Campbell at a position (lat. 41° 54′ 36″ S.; long. 174° 11′ 55″ E.) approximately 40 miles from Stations *C*.119 and *C*.122, and noted the surface temperature as 54° F. (12·2° C.).

Prof. H. B. Fell, of Victoria University of Wellington, has brought to our notice a record of another observation by Mr. Abernethy, some time shortly before October 20, 1952, when the sea-floor off Cape Campbell was covered with dead *Pyrosoma* at a depth of 100 m. The animals were in an advanced state of decomposition, and were present in quantity in the trawl. Mr. Abernethy informs us that fishermen in this area frequently take dead *Pyrosoma* in this condition at certain times of the year.

The nature of the bottom in the photographs taken is an interesting commentary on conditions apparently suitable for *Pyrosoma*. The bottom is of clean-swept cobbles, completely lacking in the usual fauna found in nearby rocky bottom areas where there is a certain amount of muddy matrix, and indicates a fairly strong current. Measurements of the bottom current were made at Station *C*.122 by Mr. A. E. Gilmour of this Institute, and were found to vary between $\frac{1}{2}$ and $\frac{3}{4}$ knot at 10 in. above the bottom. Surface currents were 1–4 knots, depending on the state of the tidal-cycle. These velocities are

representative of average conditions in the relatively constricted passage through Cook Strait. It is reasonable to infer from this that the animals can maintain their position on the bottom despite the current. It may well be that the occurrence demonstrated a positive reaction in *Pyrosoma atlanticum* towards the least rapidly moving water in their immediate vicinity, since the whole water column above them would be moving at a greater rate.

The photographs for this work were taken by Mr. G. R. T. Clacey, of the New Zealand Electricity Department, with an underwater camera, developed in consultation with the New Zealand Oceanographic Institute and the Photographic Section of the Department of Scientific and Industrial Research.

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Inhibitory Effect of Colchicine upon the Transplantable Fibroma of the Skin in the Newt *Triturus taeniatus*

Recently, we described a multiple fibroma of the skin in the newt *Triturus taeniatus* which was characterized by an enlargement of the adepidermal reticular network[1–4] and appeared to be transplantable in the same animal[3,4]. The preliminary transplantation experiments were continued to establish the effect of a colchicine treatment. The material for these experiments was obtained by breeding the normal animals of the first litter in which the tumour was observed[3,4]. Fragments of tumour tissue from the surroundings of small tumours, in which an enlargement of the nodular swellings of the adepidermal reticular network could already be expected, were transplanted to a perfectly tumour-free area of the same animal, preferably in the tail base region. In 105 of the 128 cases a distinct tumour developed after about 3 weeks at the location of the transplantation, whereas in the 23 negative cases the transplanted material had been almost completely resorbed. After 3 weeks in 83 of the 105 tumour cases treatment with colchicine was applied, the remaining 22 animals being used as controls. This colchicine treatment consisted in giving once a week an intraperitoneal injection of colchicine–saline solution (0·0017 mgm. colchicine). The method of preparing the solution for injection was as usual[5–7]. The experiment lasted 70 days.

Comparing the area diagrams which were made of the tumours, it was clear that the colchicine had an inhibitory effect on the growth of this fibroma.

The tumours of the colchicine-treated animals as well as of the control animals were examined histologically, and particularly the adepidermal reticular network was studied with the aid of Pap's ammoniacal silver method as modified by Mitchell and Wislocki[8] (counterstain paracarmine) and Bodian silver–proteinate (counterstain orange *G*).

The tumours of the control animals showed the normal development of this fibroma, in which the following stages already described[3,4] were observed: (1) enlargement of the nodular swellings of the adepidermal reticular network; (2) continued enlargement of the nodular swellings and concentration of fibroblasts in their surroundings; (3) formation of new fine fibrils radiating from the enlarged nodular swellings, a densely structured network thus being formed around the concentrated fibroblasts; (4) fusion of the concentrated masses of fibroblasts to larger complexes. The enlarged nodular swellings are probably induction centres which, with the aid of certain chemical substances, cause the local concentrations of the fibroblasts.

In the tumours of the colchicine-treated animals particularly the enlargement of the nodular swellings and the concentration of the fibroblasts appeared to be disturbed. The inhibitory effect of the colchicine is consequently in all probability an inhibition of these processes. The fact that in the colchicine-treated animals these processes, as well as the tumour growth, had come to a stop is an important argument for the assumption that these processes of the adepidermal reticular network play an important part in the development of this skin fibroma.

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Effect of Infection with Myxomatosis Virus on the Endoparasites of Rabbits

The widespread and common occurrence of endoparasites in free-living Australian wild rabbits, *Oryctolagus cuniculus* (L.), prompted an investigation into any effect they might have on the severity of infectious myxomatosis in partially resistant animals, or in cases due to attenuated strains of the virus. Although the results so far obtained are based on a small number of rabbits and are insufficient to answer this complicated problem fully, results collected simultaneously on the behaviour of parasites, especially *Graphidium strigosum*, in virus-infected hosts are interesting and worth recording.

Rabbits infected naturally with *Eimeria* spp. (coccidia), *G. strigosum*, and *Trichostrongylus retortaeformis* were caught in the field at the approximate age of six weeks for the purpose of testing for the degree of genetic resistance to myxomatosis. Prior to inoculation with *K.M.* 13 attenuated strain of virus[1] at about five months, they were kept in the laboratory under conditions which excluded the possibility fo re-infection. For one week before inoculation, and then throughout the course of the disease, fæcal counts of oocysts and nematode eggs were carried out at 2-day intervals in 12 rabbits.

Statistical analysis of the results showed that after generalization of the virus in the host, seven days after inoculation, a significant ($P < 0·05$) reduction in the numbers of oocysts and ova occurred, which lasted for approximately 2 weeks—a period coinciding with the acute stage of the disease. The reason for this was not studied specifically, and it is only suggested that the changing metabolism in the host or its increasing body temperature may have induced

conditions unsuitable for the development of the parasites. Similarly, Reid *et al.*[2], studying the effects of *Ascaridia galli* on chicks with infectious bronchitis, recently reported a highly significant reduction of worms due to the virus infection; and common observation suggests that the burden of worms decreases markedly in dogs affected by distemper (Soulsby, E. J. L., personal communication).

After the reduction induced by the virus infection a significant ($P < 0{\cdot}05$) increase was recorded generally in numbers of ova but not of coccidia. In only a few animals were counts unchanged—these survived, whereas all those showing an increase died, some when complete recovery from myxomatosis had been expected. Post-mortem examination revealed that the level of infestation with *G. strigosum* was very high in some animals; more than 5,000 worms per rabbit were counted in some cases—a degree of infestation not previously recorded in large samples of normal rabbits caught in the field[3]. These worm populations consisted of newly hatched adults and fourth-stage larvæ, in spite of the fact that all rabbits had been protected from re-infestation with endoparasites.

Michel[4], while studying the problem of the resistance of rabbits to infestation with *T. retortaeformis*, found that in hosts already infested the development of superimposed larvæ is inhibited, and they remain dormant in the intestinal mucosa until conditions become more favourable. It seems that a similar mechanism operates in infestation with *G. strigosum*. The expulsion of adult worms during the early stages of infection with the virus, and the lowered resistance of the host due to the prolonged disease, probably create conditions under which dormant larvæ may resume development and so aggravate the severity of myxomatosis.

I reported earlier another form of interference between endoparasites and virus, which was manifested by inhibition of myxomatosis symptoms and premature death in heavily parasitized animals[5].

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Long-term Survival of Irradiated Mice treated with Homologous Tissue Suspensions

Recently, Barnes *et al.*[1] reported the survival for 150 days of *CBA* mice subjected to a dose of 950 r. X-radiation and treated with spleen or liver suspensions from new-born or unborn *C57BL* mice. In an attempt to clarify the secondary phase of the irradiation death syndrome, Uphoff[2] observed the 90-day survival of $(C57BL \times DBA/2)F_1$ hybrids subjected to 800 r. X-radiation following injections of suspensions made from *C57BL* or *DBA/2* tissues. She reported that the use of fœtal hæmatopoietic tissues precluded the secondary phase of the irradiation syndrome for 90 days after irradiation, whereas injection of bone marrow suspensions did not.

Table 1. Effect of *CF* No. 1, *C57BL/6*, or LAF_1 Tissue Suspensions on Survival of 10- to 12-week-old *CF* No. 1 Female Mice exposed to 750 r. Total-body X-Radiation.
Controls consisted of 10 untreated *CF* No. 1 mice, all of which survived 270 days; 9 survived 400 days and 7 survived 500 days; 2 were still alive at 910 days

Donor tissue	No. of mice treated	No. surviving at intervals shown (days) 28	150	270	400	500	Day of last death
CF No. 1 bone marrow (7- to 8-week mice)	36	23	20	17	8	2	515
C57BL/6 bone marrow (7- to 8-week mice)	36	3	0	0	0	0	121
CF No. 1 baby spleen	44	24	16	9	4	1	525
C57BL/6 baby spleen	50	30	9	5	1	0	406
LAF_1 baby spleen	34	18	11	6	2	0	483
CF No. 1 embryo liver	45	34	31	24	16	1	546
C57BL/6 embryo liver	69	27	18	11	2	1	497
Locke's solution	75	5	3	1	0	0	365

In 1956[3] we observed that no secondary deaths occurred when lethally irradiated rabbits were injected with embryonic or new-born mouse tissues, and that rabbits so treated were alive after 150 days. Many of these rabbits are, in fact, still alive after three and a half years. We had previously reported in 1954[4] that suspensions made from fœtal *CF* No. 1 mouse liver, or spleen and liver from new-born mice, were more effective, on the basis of cell counts, than suspensions of mature tissue in enhancing the 30-day survival of irradiated (900 r.) mice of the same strain. *CF* No. 1 mice which were treated with hæmatopoietic tissues from young or unborn *CF* No. 1, *C57BL/6*, or LAF_1 mice following 750 r. total-body X-irradiation have now lived out their life-span, and the long-term survival results are shown in Table 1. Irradiated *CF* No. 1 mice survived longer when injected with fœtal liver or spleen suspensions from new-born mice than when treated with an equal number of *C57BL/6* or *CF* No. 1 bone marrow cells.

Although the *CF* No. 1 strain is no longer maintained by strict inbreeding, post-irradiation treatment with *CF* No. 1 fœtal or new-born tissues resulted in longer survival than did similar treatment with *C57BL/6* or LAF_1 tissues.

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Edna K. Marks
Evelyn O. Gaston

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* Operated by the University of Chicago for the United States Atomic Energy Commission.

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Red Muscle as a Possible Character for the Identification of Sharks

In a previous communication, the relative distribution of vitamins between the red muscle and the ordinary muscle in fish was reported[1]. The relation between the proportion of red muscle present and the activity of different species was pointed out, and the possible function of the red muscle as an organ proposed.

Since then studies have been in progress, including recording the extent of the red muscle in the different species investigated. By chance these studies have led to an interesting observation in the two closely related pelagic sharks of the family Isuridae or mackerel sharks.

The main studies were carried out with the porbeagle (*Lamna nasus*[2], syn. *Lamna cornubica*[3] or *Isurus nasus*[4,5]), the mackerel shark caught off the coast of Norway. Although this species is caught also in the warmer parts of the Atlantic and in the Mediterranean, it seems present mainly in the northern part of the Atlantic. The very closely related sharp-nosed mackerel shark or mako (*Isurus oxyrinchus*) lives mainly in the warmer parts of the Atlantic and is very rarely caught off the coast of Norway or in the north.

The two species are very alike, but certain distinctive characters, such as the teeth and the position of the dorsal and ventral fins, can be used for their identification. The porbeagle also has a stouter trunk than the mako. They are both very active and strong-swimming species which prey mainly upon shoals of scombroids, clupeids and other small fishes.

By chance a 'trunk' of a mackerel shark caught off the coast of Morocco was brought to this Institute for comparison with regard to palatability and quality with the porbeagle caught off the coast of Norway. During routine sampling and recording of the red muscles of these sharks, a very typical difference in the location of the red muscle in the two species was observed. While the red muscles in the porbeagle only extended partly along the trunk and were mainly situated close to the vertebra and the body-cavity, the red muscles in the mako extended all along the trunk and did not lie directly up against the vertebra. Fig. 1 shows transverse sections of the two species at the thickest part of the red muscles. Both fishes had a gutted weight of 13 kgm. Differences caused by stages in development thus could be discounted. Both species are very alike, and it is actually very difficult to identify them as delivered at the fish market, although the transition from stone-grey colour on the dorsal to white on the ventral side changes abruptly on the porbeagle and gradually on the mako. The present observation shows that the position of the red muscle in this case gives a good character for the distinction between closely related species. To my knowledge, this character has never been proposed or used for identification purposes in fishery research. It is apparently specially useful for pelagic species with distinct red muscles. The usefulness of the proposed character will have to be established by further investigations by marine biologists working in this field.

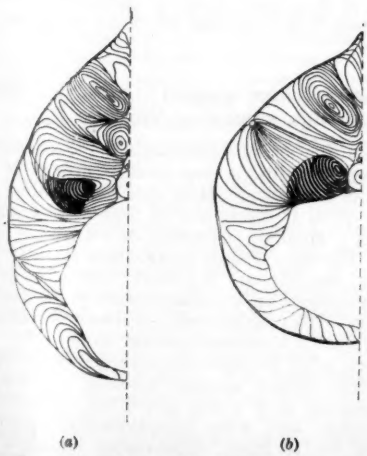

Fig. 1. Transverse sections of the sharks: left, mako (*Isurus oxyrinchus*); right, porbeagle (*Lamna nasus*), showing the position of the red muscles

I wish to express my thanks to Mr. Gunnar Rollefsen, director of marine research, for encouraging discussions, and to Mr. Klaus Olsen, fish inspector at the Directorate of Fisheries, for supplying the specimens.

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Origin of Indirect Flight Muscles in Primitive Flies

It is generally supposed that among endopterygote insects the flight muscles of the adult first arise in the pupal stage. For example, in the higher Diptera (*Drosophila*[1,2], *Calliphora*[3]) the development of the indirect flight muscles is said to begin at pupation when free myoblasts adhere to or penetrate certain larval muscle fibres. In the early pharate[4] pupa of the Neuroptera[5] and Coleoptera[6,7], larval muscle is directly transformed into adult muscle: in certain larval muscles some nuclei degenerate and others undergo mitosis and persist as the nuclei of the adult flight muscle. In some Hymenoptera (*Momonella*[8]) the adult muscles arise from free myoblasts as in the higher Diptera, whereas in others, such as the honeybee[9], the imaginal myoblasts are contained in the larval muscle, as in the Neuroptera and Coleoptera.

In the Simuliidae, however, the indirect flight muscles and the tergal depressor of the trochanter develop quite independently of the larval muscles in all post-embryonic stages. So far as may be judged from the account given by Hulst[10], the indirect flight muscles of *Culex* also develop independently of the larval muscles. In the mesothorax of the Simuliidae there are six groups of indirect flight muscles. These consist on each side of 6 dorso-longitudinal, 2 oblique dorsal, 2 tergo-meral, 2 tergo-sternal, 3 outer tergo-pleural, and 2 inner tergo-pleural. In *Simulium ornatum* Meig., in which there are six larval instars, the imaginal disks of the indirect flight muscles and that of the tergal depressor of the trochanter are present in the second instar larva 1·3 mm. long. In the first instar larva the disks of the dorso-longitudinal muscles are present but those of the dorso-ventral muscles have not yet been identified with certainty.

In the young larva the disks of the indirect flight muscles consist of slender strands attached at either end to the epidermis but not to the cuticle (Fig. 1). Each of these strands is a sleeve of sarcolemma enclosing a syncytium with a few nuclei. The strands grow in length and thickness as the larva grows so that their size relative to that of the mesothorax is maintained. The nuclei are similar in size in all

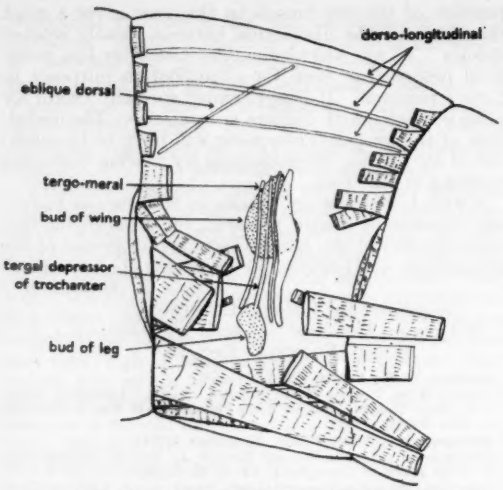

Fig. 1. Mesothorax of penultimate larval instar of *Simulium ornatum* Meig. Larval muscles shaded, disks of imaginal muscles unshaded

larval stages : 4–6μ. In very young larvæ the strands are often thinner than the nuclei so that they bulge where nuclei are present. As the larva grows the number of nuclei increases by mitosis. The mitotic divisions appear indistinguishable from those of the epidermis.

After the larval–pupal moult but before the larval–pupal ecdysis, that is, in the pharate[4] pupal stage, there is a rapid increase in the size of the imaginal strands, and mitotic figures are numerous both during the day and the night. Before the larval cuticle is shed, mitosis appears to have come to an end, and the nuclei have become arranged in longitudinal rows. Also before the larval–pupal ecdysis the imaginal strands have become divided so that there are now clearly 17 on each side plus the tergal depressor of the trochanter. It is during the pharate pupal period that differences between the organization of the fibrillar tergal depressor of the trochanter and the indirect flight muscles are first discerned. The indirect flight muscles and the tergal depressor of the trochanter continue to grow in size after the larval cuticle is shed and after the pupal–adult moult. At this time growth in volume is accompanied by a degeneration of the nuclei.

In the young pharate pupa the shape of the thorax and the relative proportions of its three segments are as in the last larval instar. The great increase in the extent of the mesothorax and the great reduction in the extent of the pro- and meta-thorax occur during the pharate pupal period, especially near the end of this period. The epidermis of the thorax assumes its final 'humped' shape at the moment that the larval cuticle is being shed, and it is this change in shape that effects the first split in the larval cuticle. The change in shape is brought about by an increase in turgor pressure due to the contractions of the muscles carried over directly from the larval stage, but it is made possible by the enormous increase in area of the mesothoracic epidermis that occurs after the larval–pupal moult but before the larval cuticle is shed. After the larval–pupal ecdysis, the shape of the thorax is essentially that of the adult, although in some other Nematocera, such as the Thaumaleidae[11], the metathorax is reduced in the pharate pupal period and the prothorax in the pharate adult period.

The indirect flight muscles and the tergal depressor of the trochanter do not become contractile, cross striated, or birefringent until some hours after the first layers of the adult cuticle have been secreted. It therefore follows that they can play no direct part in the change of shape that occurs when the pupa sheds the larval cuticle, as they have been said to do in *Drosophila*[12]. During growth the muscles do not shift their attachments to the epidermis, but the epidermis of different parts of the mesothorax grows at different rates. It is this differential growth of the epidermis that directly determines changes in the position and orientation of the indirect flight muscles, changes that are particularly evident as the newly enlarged epidermis of the mesothorax is stretched during the shedding of the larval cuticle. So far as the mesothorax is concerned, all larval muscles except one are carried over without evident modification into the pupal stage, and no new muscles that function in the pupal stage are developed in that stage. Histolysis of the larval muscles becomes evident only in the pharate adult stage, and their destruction is not completed until about 30 hr. (at 8° C.) after the pupal–adult moult.

In some other Diptera–Nematocera the indirect flight muscles would appear to develop in a similar way. The imaginal disks of the dorsal longitudinal or both dorsal longitudinal and dorso-ventral muscles have been identified in the last larval instar of the Tipulidae (*Taphrophila*, *Geranomyia*), Dixidae, Culicidae (*Aedes aegypti* L.), Chironomidae (*Chironomus*), and Thaumaleidae.

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Goniotrichum elegans: a Marine Red Alga requiring Vitamin B_{12}

The cultivation of multicellular marine algae under laboratory conditions has always proved to be a matter of difficulty. Most species die after a few months even if cultivated in seawater or enriched seawater. Henkel[1] succeeded in cultivating *Bangia pumila* through several generations in an artificial medium, but she did not work with pure cultures. Koch[2] produced an axenical culture of *Porphyridium cruentum*. His medium was not, however, chemically defined since it contained natural water.

I have tried to cultivate several marine algae in completely defined nutrient medium. To that purpose medium *ASP* 6 was used[3], but without copper and cobalt, and with potassium-glycerophosphate replaced by 10 mgm. dipotassium hydrogen phosphate per litre. *Goniotrichum elegans* (Chauv.), a small epiphytic member of the Bangioideae with a

Table 1. GROWTH OF *Goniotrichum elegans* WITH COBALT OR VITAMIN B_{12}

The figures represent the total dry weight produced in all six flasks of each series. Incubation time, 4 weeks

No addition	Dry weight of alga (mgm.)	
	Cobalt (10 μgm./l.)	B_{12} (1 μgm./l.)
0·9	0·7	6·9

dichotomously ramified monosiphonous thallus, was among the species treated. It produced good growth in *ASP* 6, and since May 1957 it has been cultivated through repeated re-inoculations in 100-ml. 'Pyrex' flasks with 25 ml. nutrient solution per flask, in fluorescent light (900 lux) at 20° C. Diatoms and other small algae were removed by washing and careful manipulations. By treating small samples of the alga with phenoxymethylpenicillin (1,000 units per ml.) combined with streptomycin sulphate (Glaxo, 500 units per ml.)[4] of contaminating bacteria were killed and a completely axenical culture was obtained. The treatment had to proceed for 12–14 days to give a satisfactory result. The purity has repeatedly been controlled according to the test described by Pringsheim[5]. When it was used in the following experiments the strain had remained axenical for 3½ months.

The requirement of growth substances was studied. The medium *ASP* 6 contains all available vitamins. In the first experiment the exclusion of the vitamins did not seem to slow down growth. The experiment was repeated, however, and as inocula the algae from the vitamin-free series of the former experiment were used. The following series were inoculated: (*a*) without vitamins; (*b*) with B_2, B_{12}, pyridoxamine and folic acid, run through sterile glass filter and added aseptically; (*c*) with the remaining 11 vitamins, sterilized together with the nutrient solution. Visible growth appeared only in series *b*.

Several marine algae and bacteria have turned out to be dependent[6] on an exogenous source of vitamin B_{12}. This vitamin was therefore suspected to be the active member of the vitamin mixture. Since in all experiments hitherto no cobalt had been added to the nutrient solution, there was a possibility that B_{12} acted only as a cobalt source[7]. In a following experiment cobalt (10 μgm. per litre) and B_{12} (1 μgm. per litre) were added to two different series (Table 1). As inocula, pieces of *Goniotrichum* from the vitamin-free series of the preceding experiment were used, which had been cultivated for 50 days, and during this time transferred three times into new cobalt- and vitamin-free nutrient solution. The inocula were pale and partly dead.

As Table 1 shows, good growth appeared only in the B_{12} series, while the addition of cobalt had no effect. Ericson and Lewis[8], who worked with labelled cobalt and B_{12}, found that some red algae could transfer cyanocobalamin into other B_{12} factors, though additions of B_{12} gave no stimulation. They assumed that B_{12} was produced by bacteria and then accumulated by the algae, but they had no proof of the vitamin being necessary for the algae as they did not work with pure cultures. The experiments with *Goniotrichum elegans* thus add a member of the Rhodophyta to the list of vitamin B_{12} heterotrophic algae. Pintner and Provasoli[9] have shown that a marine red pigmented blue-green alga, *Phormidium persicinum*, also needs exogenous vitamin B_{12}. This similarity of vitamin requirement may perhaps support the theory of a relationship between blue-green algae and red algae.

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Effect of Boron on the Rooting of Clematis Cuttings

BORON has been observed to stimulate the rooting of large-flowered hybrid clematis cuttings. In two studies recently carried out, increased percentages of cuttings rooted and the rooting process was accelerated by boron when it was used in combination with the root-initiating hormone, indole butyric acid.

Previously, stimulation by boron of the rooting of *Phaseolus vulgaris* L. cuttings was noted by Hemberg[1] and verified by Gorter[2]. Although relatively little is known about the nature of this stimulative action, Hemberg[1] and Rehm[3] have stated that root growth, and not root initiation, is favoured by this element.

In the first study, 180 two-node cuttings were taken on June 14, 1958, from new growth of clematis selection 234, a seedling of Crimson Star. Cuttings were divided into four lots of 45 each and the bases of the cuttings in each of these lots were soaked for 12 hr. in one of the following aqueous solutions: 50 p.p.m. indole butyric acid; 50 p.p.m. boron, supplied as boric acid; 50 p.p.m. indole butyric acid plus 50 p.p.m. boron; and water. Following these treatments the cuttings were placed in washed sand on the propagating bench under an intermittent mist system which came on for 15 sec. out of every 3 min. during the daylight hours. The temperature of the sand was maintained at approximately 75° F. by heating cables. Air temperature was 65° F. at night and usually higher during the day, occasionally reaching a maximum of 85° F.

The percentage of cuttings rooted in each treatment after 32 days and after 54 days is recorded in Table 1.

Table 1. RESPONSE OF CLEMATIS SELECTION 234 TO THE ROOTING TREATMENTS

Treatment	Rooting	
	After 32 days (per cent)	After 54 days (per cent)
Water	6·7	33·3
Indole butyric acid	24·4	55·6
Boron	17·8	32·2
Indole butyric acid + boron	66·7	86·7

It is evident from these figures that boron stimulated the rooting of cuttings when it was used in combination with indole butyric acid, and to a lesser extent when it was used alone. A comparison of the rooting percentages at the two observation dates indicates indole butyric acid plus boron accelerated rooting in addition to increasing the percentage of cuttings which rooted.

Table 2. Response of Nine Clematis Selections to the Rooting Treatments

Selection No.	Rooting after 36 days			
	Water (per cent)	Indole butyric acid (per cent)	Boron (per cent)	Indole butyric acid + boron (per cent)
181	100	60	80	90
51	60	80	20	90
217	0	50	20	100
169	20	40	40	50
31	80	90	100	90
32	80	90	60	80
94	0	70	0	100
54	40	60	40	70
159	40	80	40	90
Treatment average after 36 days	46·7	68·9	44·4	84·4
Treatment average after 56 days	53·3	74·4	53·3	85·6

In the second study 30 two-node cuttings were taken on July 24, 1958, from each of 9 numbered clematis selections of diverse parentage and were given the four treatments described in the first study. Cuttings were divided into lots of unequal size so that 10 cuttings of each selection received the indole butyric acid and indole butyric acid plus boron treatments while 5 cuttings of each selection received the boron and the water treatments. The rooting conditions on the cutting bench were the same as those described in the first study. Table 2 shows the treatment averages after 36 days and 56 days and the percentage rooting of each selection after 36 days.

Selections varied considerably in response to the treatments, but the treatment averages in general substantiated the results obtained in the first study. In particular, the high rooting percentage of the indole butyric acid plus boron treatment and the acceleration of the rooting process by the boron in that treatment agreed with the results of the former study. A notable exception is the lack of increased rooting in the boron treatment as compared with the water check. This lack of increased rooting seems to support the views of Rehm[3] and Hemberg[1] that boron promotes root growth and not root initiation. If applied to the indole butyric acid and indole butyric acid plus boron treatments, this concept implies that cuttings in both treatments may have formed the same number of root initials as a result of the initiation stimulus of indole butyric acid, but that more roots grew in the treatment with indole butyric acid plus boron due to the growth stimulus of boron. Nevertheless, other possible explanations of this boron stimulation, such as a boron enhancement of the effectiveness of indole butyric acid in stimulating root initiation, seem equally plausible in these studies. Further investigation is necessary to elucidate the role or roles of boron in rooting cuttings.

Results of studies which indicate that boron also enhances the rooting of cuttings of certain varieties of rhododendrons and English holly (*Ilex aquifolium* L.) will be published elsewhere.

I am indebted to Dr. L. T. Blaney for his helpful suggestions.

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Crowned Cranes in Cambridgeshire

Four crowned cranes (*Balearica pavonina*) recently appeared in an area of arable and marshy country in Cambridgeshire. This species, so far as we know, *has not previously been described as occurring* at large in Britain, although one specimen was shot in Ayrshire in 1871, and had "doubtless escaped from captivity"[1].

The birds appeared in their present haunts in August 1958, or possibly earlier. They were last seen on January 24. Two were adult; the other two, from their more buff-coloured plumage, appeared to be immature.

All exhibited the straw-coloured crown characteristic of the species and the elongated secondaries typical of cranes. The white facial patch behind the eye was very conspicuous; the red area behind it was clearly seen but more difficult to define. The neck appeared dark grey or black according to the lighting.

In flight the neck and legs were extended, and with the back, formed a dorsal convex curve. The crown was laid close to the neck. The large white wing was edged at the tip and along its hind margin with black primaries and secondaries. It presented a digitated appearance at its extremity. A gap in the secondaries could be seen when the wing was viewed from below. The birds' flight was powerful and at times swift, direct and purposeful when compared with that of the heron. Landing was preceded by a glide, and lowering the legs produced a braking effect by opposing the under surface of the wings to the direction of flight. The birds were usually seen flying in line ahead, and any tendency for the group to become split up was checked by a repeated honking call from the leader.

Owing to the wet summer in 1958, several fields of barley in the locality now frequented by these cranes were left unharvested. They have been commonly observed feeding on the uncut barley and gleaning among the stubble.

They were alert and very shy, and careful stalking has been required to approach within fifty yards. On taking wing they travelled 400–1,000 yards and then once more alighted to continue feeding. Once the larger of the two adults was seen to perch on a tree, where it acted as sentinel. The remaining three partially concealed behind a broken hedge could be seen with necks craned in a characteristic posture.

From their extreme wariness we do not believe that these birds have escaped from captivity; but this cannot be ruled out without a complete record of recent escapes of this species. We have now had them under observation for more than two months and attempts to photograph them, with or without 'hides', have met with little success. We should add that since January 10 only three cranes have been seen; the fate of the fourth, an immature bird, is unknown.

We are indebted to Prof. R. A. McCance for valuable help and advice.

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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, February 23

ROYAL GEOGRAPHICAL SOCIETY (at 1 Kensington Gore, London, S.W.7), at 5 p.m.—Mr. J. G. D. Pratt and Dr. Hal Lister: "Glaciological Research on the Trans-Antarctic Expedition".

INSTITUTION OF ELECTRICAL ENGINEERS, RADIO AND TELECOMMUNICATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Scientific Papers.

UNIVERSITY OF LONDON INSTITUTE OF EDUCATION (in the Assembly Hall, Malet Street, London, W.C.1), at 5.30 p.m.—Dr. R. S. Peters: "Education and Explanation—an Examination of Ways in which Theories of Learning are Relevant".*

UNIVERSITY OF LONDON (at King's College, Strand, London, W.C.2), at 5.30 p.m.—Prof. E. W. Montroll (University of Maryland): "Theory of Vibration of Crystal Lattices".* (First of three lectures on "Statistical Mechanics". Further lectures on February 24 and 25.)

INSTITUT FRANCAIS DU ROYAUME-UNI (at Queensberry Place, South Kensington, London, S.W.7), at 8.30 p.m.—Programme of French Scientific Films. (By invitation obtainable from the Scientific Office, French Embassy, 22 Wilton Crescent, S.W.1).

Tuesday, February 24

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. W. B. Emery: "Excavations at Buhen, Sudan".*

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street London, W.C.1), at 5.30 p.m.—Prof. G. C. Drew: "Aspects of the Investigation of Skilled Performance".*

SOCIETY OF INSTRUMENT TECHNOLOGY, CONTROL SECTION (at Manson House, Portland Place, London, W.1), at 6 p.m.—Symposium on "Automatic Weight Control in Industry".

SOCIETY FOR ANALYTICAL CHEMISTRY, PHYSICAL METHODS GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Meeting on "The Analysis of Intact Samples".

ROYAL AERONAUTICAL SOCIETY (at 4 Hamilton Place, London, W.1), at 7 p.m.—Dr. A. E. Russell, Mr. C. Abell and Dr. E. Warlow-Davies: "The Flight Development of an Aircraft Before and During its Operation".

Wednesday, February 25

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1.), at 5 p.m.—Dr. J. L. Knill: "The Tectonic Pattern in the Dalradian of the Craignish-Kilmelfort District, Argyllshire"; Dr. P. Clifford: "The Geological Structure of the Loch Luichart Area, Ross-shire" (to be read by Prof. J. Sutton).

ROYAL SOCIETY OF MEDICINE, ENDOCRINOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Discussion on "The Chemical, Pharmacological and Clinical Aspects of the 19-nor-steroids". Opening Speakers: Dr. W. Klyne, Dr. J. C. Eaton, Dr. T. M. Chalmers, Dr. G. I. M. Swyer, Dr. Margaret C. N. Jackson and Mr. J. A. Chalmers.

INSTITUTE OF FUEL (at the Institution of Civil Engineers, Great George Street, London, S.W.1), at 5.30 p.m.—Dr.-Ing. H. Lent: "Investigations in Germany concerning Atmospheric Pollution".*

INSTITUTION OF MECHANICAL ENGINEERS, APPLIED MECHANICS GROUP (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Discussion on "The Significance of Thermal Stresses in Design".

SOCIETY OF CHEMICAL INDUSTRY (joint meeting of the FOOD GROUP and the MICROBIOLOGY GROUP, at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "Cheese Manufacture and Microbiology". Dr. K. Mabbit: "Microbiological Aspects"; Miss V. Cheke: "Technological Aspects".

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. E. D. Swann: "Patents and the Radio Engineer".

OIL AND COLOUR CHEMISTS' ASSOCIATION (at Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Mr. D. M. James: "The Moisture Resistance of Cold-Cured Epoxide Resin Paints".

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (at Birkbeck College, Malet Street, London, W.C.1), at 8 p.m.—Annual Meeting. Paper by Prof. Angus Campbell.

Thursday, February 26

UNIVERSITY COLLEGE (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. K. A. Sinnhuber: "Alexander von Humboldt (d. 1859), Traveller, Geographer, Philosopher".*

INSTITUTION OF INDUSTRIAL SAFETY OFFICERS (at the Royal Society of Arts, John Adam Street, London, W.C.2), at 2.30 p.m.—Mr. R. E. Tugman, M.B.E.: "The Responsibility of Management for the Prevention of Industrial Accidents" (First Alexander Redgrave Memorial Lecture).

ROYAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Miss Ann B. Glossop and Mr. D. W. Pashley: "The Direct Observation of Anti-phase Domain Boundaries in the Ordered Copper-Gold (Cu-Au) Alloy"; Mr. J. Grindlay and Mr. D. ter Haar: "On the Ferro-electric Behaviour of Potassium Dihydrogen Phosphate".

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. Peter David: "Exclusive Distribution of Certain Species of Chaetognaths"; Dr. M. H. Williamson: "Effects of Inter-Specific Competition".

PHYSICAL SOCIETY, ACOUSTICS GROUP (at the Royal Academy of Music, Marylebone Road, London, N.W.1), at 5.30 p.m.—Discussion on "Of What Use is Acoustics to the Musician?"

CHEMICAL SOCIETY (in the Lecture Theatre, The Royal Institution, Albemarle Street, London, W.1), at 7.30 p.m.—Prof. F. Hoyle, F.R.S.: "The Origin of the Elements".

Friday, February 27

INSTITUTE OF RURAL LIFE AT HOME AND OVERSEAS (at Friends International Centre, 32 Tavistock Square, London, W.C.1), at 1.15 p.m.—Mr. C. W. A. Garland: "Higher Education in British Africa".*

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion on "Characteristics of the Antarctic Ice Sheet". Chairman: Dr. J. F. Nye. Speakers: Monsieur B. Imbert, Dr. H. Lister and Mr. J. G. D. Pratt.*

INSTITUTION OF MECHANICAL ENGINEERS (at 1 Birdcage Walk, Westminster, London, S.W.1), at 6 p.m.—Informal Discussion on "Choice of Gas Temperature and Steam and Pressure Conditions in Nuclear Power Stations".

MALACOLOGICAL SOCIETY OF LONDON (at the Linnean Society, Burlington House, Piccadilly, London, W.1), at 6 p.m.—Discussion on "The Status of the Protobranchia within the Bivalve Mollusca".

MANCHESTER STATISTICAL SOCIETY, INDUSTRIAL GROUP (in the Portico Library, 57 Mosley Street, Manchester), at 6 p.m.—Dr. A. Baines: "Applications of Linear Programming Techniques to Problems of Production and Distribution".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. C. H. Waddington, F.R.S.: "Evolutionary Systems—Animal and Human".

Saturday, February 28

LONDON COUNTY COUNCIL (at the Horniman Museum, London Road, Forest Hill, London, S.E.23), at 3.30 p.m.—Dr. Guy Atkins: "African Sculpture and Western Art".*

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER IN MICROBIOLOGY—The Secretary, The Queen's University, Belfast (February 28).

RESEARCH FELLOW IN THE DEPARTMENT OF PHARMACOLOGY—The Secretary, Royal Free Hospital School of Medicine (University of London), 8 Hunter Street, London, W.C.1 (February 28).

ASSISTANT (with an honours degree in physiology or an allied subject and preferably a medical degree) IN THE DEPARTMENT OF PHYSIOLOGY—The Secretary, The University, Edinburgh (March 1).

ASSISTANT LECTURER, Grade B (with qualifications in numerical analysis) IN THE DEPARTMENT OF MATHEMATICS—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (March 2).

SCIENTIST (with at least a second-class honours degree or equivalent) at the Research and Development Laboratories, Capenhurst, Chester, to work on the development of infra-red absorptiometers and on allied infra-red and optical instrumentation problems, involving the design and use of optical and infra-red systems, techniques of absorption spectroscopy and application of modern electronic methods—The Recruitment Officer, U.K.A.E.A., I.G.H.Q., Risley, Warrington, Lancashire, quoting Ref. 2938/114 (March 2).

LECTURER or SENIOR LECTURER IN MATHEMATICS at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, March 6).

ASSISTANT LECTURER (with a good honours degree in agricultural chemistry, chemistry or physics, and preferably an interest in soil physics) IN AGRICULTURAL CHEMISTRY—The Registrar, The University, Leeds 2 (March 11).

LECTURER or ASSISTANT PROFESSOR (with a Ph.D. degree in mathematics or in applied mathematics)—The Chairman, Mathematics Department, McMaster University, Hamilton, Ontario, Canada (March 15).

READER IN BACTERIOLOGY at St. George's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 16).

READER IN MORBID ANATOMY at St. George's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (March 16).

ASSISTANT LECTURER (with special qualifications in micropalæontology) IN THE DEPARTMENT OF GEOLOGY—The Registrar, University College of Wales, Aberystwyth (March 21).

LECTURERS or ASSISTANT LECTURERS IN THE DEPARTMENT OF PHYSICS—The Registrar, The University, Leeds 2 (March 21).

MULLARD RESEARCH FELLOW (preferably with a Ph.D. degree or equivalent research experience) IN PHYSICS—The Registrar, University College of North Staffordshire, Keele, Staffs (March 30).

CHAIR OF BACTERIOLOGY in the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (March 31).

CHAIR OF ENGINEERING; CHAIR OF CHEMISTRY; CHAIR OF BIOLOGY; VICE-CHANCELLOR; and LIBRARIAN at Monash University, Melbourne, Victoria, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (March 31).

LECTURER (preferably with experience in semiconductor applications or electronic computers) IN LIGHT ELECTRICAL ENGINEERING—The Secretary, The Queen's University, Belfast (March 31).

PRINCIPAL (with high academic qualifications and appropriate educational and administrative experience)—Clerk to the Governing Body, Northern Polytechnic, Holloway, London, N.7 (March 31).

UNIVERSITY DEMONSTRATOR (with an honours degree in zoology) IN ZOOLOGY—The Secretary of the Appointments Committee of the Faculty of Biology "A", Botany School, The University, Downing Street, Cambridge (March 31).

ASSISTANT LECTURER (with appropriate qualifications, specializing in either pure or applied mathematics) IN MATHEMATICS at the University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, April 3).

IMPERIAL CHEMICAL INDUSTRIES RESEARCH FELLOWS IN BIOCHEMISTRY, CHEMISTRY, CHEMOTHERAPY, ENGINEERING, METALLURGY, PHARMACOLOGY or PHYSICS—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

TURNER AND NEWALL RESEARCH FELLOWS IN ENGINEERING, INORGANIC CHEMISTRY or PHYSICS—The Academic Registrar, University of London, Senate House, London, W.C.1 (April 30).

ASSISTANT LECTURER IN MATHEMATICS—The Secretary, Royal College of Science and Technology, Glasgow.

ASSOCIATE PROFESSOR OF PHARMACOLOGY—The Dean of Medicine, University of Alberta, Edmonton, Alberta, Canada.

HEAD (man or woman) OF THE DEPARTMENT OF CHEMISTRY—The Headmaster, Weymouth Grammar School, Weymouth, Dorset.

JUNIOR or STUDENT TECHNICIAN (preferably with experience in histological work and/or microphotography) IN THE ANATOMY DEPARTMENT—The Secretary, St. Mary's Hospital Medical School, Paddington, London, W.2.

LECTURER IN TELECOMMUNICATIONS, to teach up to the full Technological Certificate of the City and Guilds of London Institute and the Grad.Brit.I.R.E.—The Clerk to the Governors, Northern Polytechnic, Holloway, London, N.7.

LECTURER or SENIOR LECTURER IN CHEMISTRY; and a PRINCIPAL LECTURER IN EDUCATION—The Warden, University of London, Goldsmith's College, New Cross, London, S.E.14.

RESEARCH ASSISTANT (male or female) IN BIOCHEMISTRY, for work in the Research Laboratory—The Medical Superintendent, Western General Hospital, Crewe Road, Edinburgh 4.

SENIOR LECTURER (qualified to direct research and to teach to Honours Degree or Diploma in Technology levels, and preferably industrial experience in a responsible position) IN TEXTILE PHYSICS—The Registrar, Institute of Technology, Bradford 7.

SENIOR LECTURER (with good academic qualifications, and experience in automatic control, preferably involving pneumatic or hydraulic systems) IN MECHANICAL ENGINEERING—The Registrar, Loughborough College of Technology, Loughborough, quoting Ref. 1/G.

SENIOR TECHNICIAN or CHIEF TECHNICIAN (preferably with experience in biochemistry), to work at Sheffield Royal Hospital—The Bursar, Department of Medicine, The University, Sheffield 10.

TEACHING ASSISTANTS (qualified Ph.D. candidates)—Prof. H. B. Collier, Department of Biochemistry, University of Alberta, Edmonton, Alberta, Canada.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Laboratory Animals Centre. Collected Papers, Vol. 7, 1958: Report of a Symposium on the Organization and Administration of an Animal Division, held at the Royal Society of Medicine, London, 5th May 1958. Pp. 107. (Carshalton: Laboratory Animals Centre, 1958.) 10*s*. [1612

City of Leicester Museums and Art Gallery. 52nd Report to the City Council, 1st April 1957—31st March 1958. Pp. 35+4 plates. (Leicester: The Museums and Art Gallery, 1958.) [1612

University of Leeds. Publications and Titles of Theses, 1955–6. Pp. 74. (Leeds: The University, 1958.) 6*d*. [1612

Philosophical Transactions of the Royal Society of London. Series A: Mathematical and Physical Sciences. No. 991, Vol. 251 (4 December 1958): Storm Surges in the North Sea, 11 to 30 December 1954. By J. R. Rossiter. Pp. 139–160. 7*s*. No. 992, Vol. 251 (4 December 1958): The Geological Interpretation of Gravity and Magnetic Surveys in Devon and Cornwall. By M. H. P. Bott, A. A. Day and D. Masson-Smith. Pp. 161–191. 9*s*. 6*d*. (London: Royal Society, 1958.) [1612

Institution of Gas Engineers. 24th Autumn Meeting, London. Publication No. 532: 19th Report of the Chairmen's Technical Committee, 1957–58. Pp. 34. Publication No. 533: 35th Report of the Gas Education Committee, 1957–58. Pp. 33. Publication No. 534: Refractories Research in the Gas Industry. By Dr. A. T. Green. Pp. 26. Publication No. 535: The Influence of Frequency of Rotation on the Behaviour of Oxide Purifiers. By J. M. Brown, S. C. Porter and R. J. S. Thompson. Pp. 26. Publication No. 536: Experiences with Refinery Gas at Southampton. By W. F. Thorne, R. K. Harrison and J. R. Fairman. Pp. 64. Publication No. 537: Official Programme, 24th Autumn Research Meeting, London, 18th and 19th November, 1958. Pp. 8. (London: Institution of Gas Engineers, 1958.) [1612

Empire Cotton Growing Corporation. Progress Reports from Experiment Stations, Session 1957–1958. Aden Protectorate. Pp. 20. 1*s*. Republic of the Sudan. Pp. 30. 1*s*. Uganda: Cotton Research Station, Namulonge and Cotton Breeding at Serere. Pp. 67. 1*s*. (London: Empire Cotton Growing Corporation, 1958.) [1612

Notes on the Library of the Royal Institution and a List of Periodicals and Serial Publications currently Received. Pp. 28. (London: Royal Institution, 1958.) [1612

Polish Cultural Institute. Selective Quarterly Guide to Polish Periodical Literature, Vol. III, 4, 1958. Pp. 50. (London: Polish Cultural Institute, 1958.) [1612

Transactions of the Royal Society of Edinburgh. Vol. 63, Part 3 (No. 22): The Petrology of Picritic Rocks in Minor Intrusions—a Hebridean Group. By H. I. Drever and R. Johnston. Pp. 459–498+4 plates. (Edinburgh: Royal Society of Edinburgh, 1958.) 15*s*. [1612

Other Countries

Curator, Vol. 1, No. 1 (January, 1958.) (A quarterly publication of the American Museum of Natural History.) Pp. 96. Annual subscription: 5 dollars. (Special Charter Subscription Offer: Two years for 7.50 dollars.) (New York: The American Museum of Natural History, 1958.) [1612

Smithsonian Institution: Bureau of American Ethnology. Bulletin No. 168: The Native Brotherhoods: Modern Intertribal Organizations on the Northwest Coast. By Philip Drucker. Pp. iv+194. (Washington, D.C.: Government Printing Office, 1958.) 1 dollar. [1612

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Flore du Congo Belge et du Ruanda-Urundi. Spermatophytes. Tableau Analytique des Familles. Par W. Robyns. Pp. 60. Série Scientifique, No. 76: Symbiose *Rhizobium*—Légumineuses en Région Équatoriale (Deuxième Communication). Par Charles Bonnier et Jacques Seeger. Pp. 66. 80 francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1958.) [1612

Durban Museum Novitates. Vol. 5, Part 9: Welwitsch's Bat *Myotis welwitschii* Gray, a Species New to the Fauna of Kenya Colony. By David L. Harrison. Pp. 111–115. 2*s*. 6*d*. Vol. 5, No. 10: Miscellaneous Taxonomic Notes on African Birds. By P. A. Clancey. Pp. 117–142. 5*s*. (Durban: Durban Museum, 1958.) [1612

United States Department of Agriculture. Production Research Report No. 18: Russian Thistle Distribution in Southern Idaho and Eastern Oregon in Relation to Beet Leafhopper Populations. By J. R. Douglass and H. C. Hallock. Pp. 20. (Washington, D.C.: Government Printing Office, 1958.) 10 cents. [1612

Suomen Geodeettisen Laitoksen Julkaisuja. Veröffentlichungen des Finnischen Geodätischen Institutes. No. 49: Die Zeiten von Sonnenschein, Dämmerung und Dunkelheit in Verschiedenen Breiten. Von Pentti Kalaja. Pp. 63. No. 50: Astronomische Azimutbestimmungen auf den Dreieckspunkten in den Jahren 1938–1952. Von V. R. Ölander. Pp. 90. (Helsinki: Finnischen Geodätischen Institutes, 1958.) [1612

Rules for the Preparation of Manuscripts and Bibliographies with a List of Abbreviations of Titles of Current Medical Periodicals. Pp. 18. (Basel and New York: S. Karger, 1958.) 0.50 dollars; 3*s*. 4*d*. [1612

Buletinul Institutului Politehnic din Iaso. Serie Noua. Tomul III (VII), Fasc. 3–4. Pp. viii+360. (Iasi: Institutului Politehnic, 1958.) [1612

Les Cahiers Techniques du Centre National de Co-ordination des Études et Recherches sur la Nutrition et l'Alimentation. No. 1: Méthodes d'Évaluation de la Valeur Nutritive des Protéines. Par Jean Adrian et Alain Rerat. Pp. vii+94. No. 2: Méthodes Indirectes de Mesure de la Graisse Corporelle des Mammifères. Par Bernard Louis Dumont. Pp. iii+95–158. (Paris: Centre National de la Recherche Scientifique, 1958.) [1612

Malaria Eradication: a Plea for Health. Pp. 12. (Geneva: World Health Organization, 1958.) [1612

The Egyptian Journal of Botany, Vol. 1, No. 1, 1958. Pp. ii+96. Annual Subscription: 100 P.T.; 21*s*.; 3 dollars. (Cairo: Botanical Society of Egypt, 1958.) [1612

Smithsonian Contributions to Astrophysics. Vol. 2, No. 13: Optical Properties of Saturn's Rings. 1: Transmission. By Allan F. Cook, II. and Fred A. Franklin. Pp. 377–383. (Washington, D.C.: Government Printing Office, 1958.) 20 cents. [1612

Bernice P. Bishop Museum, Honolulu. Bulletin 219: Subsistence Agriculture in Melanesia. By Jacques Barrau. Pp. iv+111. (Honolulu: Bernice P. Bishop Museum, 1958.) [1612

Fiskeridirektoratets Skrifter. Serie Havundersøkelser. Vol. 12, No. 2: The Herring from the Fuglsetfjord—a Supplement to "The Østerbø Herring." By Thorolv Rasmussen. Pp. 8+1 plate. (Bergen: A. S. John Griegs Boktrykkeri, 1958.) [1612

Symposium on Design for Tropical Living, Durban, 18th October, 1957. (Arranged by The Natal Regional Research Committee of the South African Council for Scientific and Industrial Research and the University of Natal.) Pp. vii+222. (Pretoria: South African Council for Scientific and Industrial Research, 1958.) [1612

University College, Ibadan, Nigeria. Calendar, 1958–59. Pp. 80. (Ibadan: University College, 1958.) [1612

World Health Organization. Monograph Series, No. 41: Principles of Administration Applied to Nursing Service. By H. A. Goddard. Pp. 106. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) 12 Swiss francs; 20*s*.; 4 dollars. [1612

Fisheries Research Board of Canada. Progress Reports of the Atlantic Coast Stations, No. 70 (September, 1958.) Pp. 36. General Series Circular No. 32: Useful Publications for Oyster Farmers of the Maritimes. By J. C. Medcof. Pp. 3. (Ottawa: Queen's Printer, 1958.) [1612

Commonwealth of Australia: Australian Defence Scientific Service. Defence Standards Laboratories Technical Note No. 50: Interstitial Patterns. By A. J. C. Hall and J. G. Hayes. Pp. 14+1 plate. (Maribyrnong: Department of Supply, Defence Standards Laboratories, 1958.) [1612

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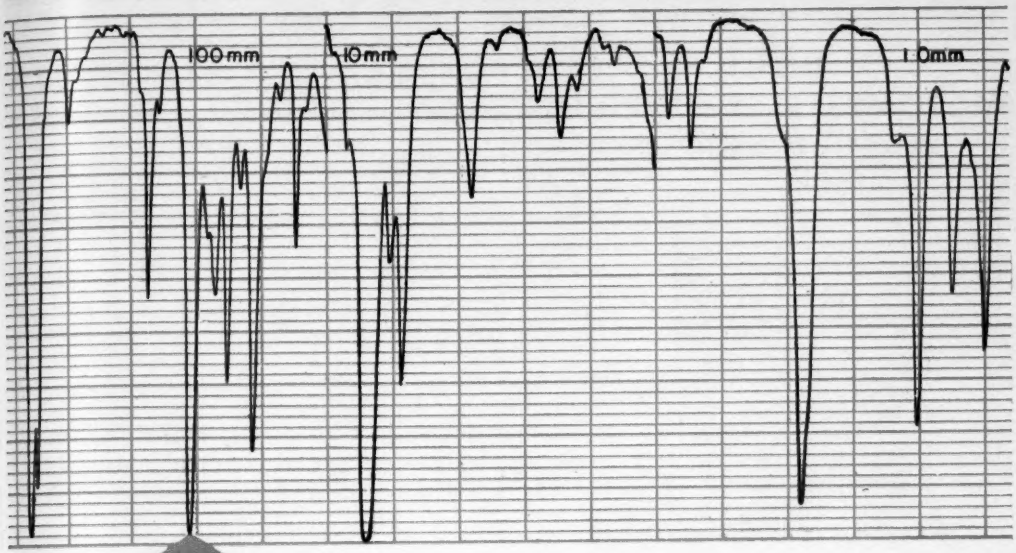

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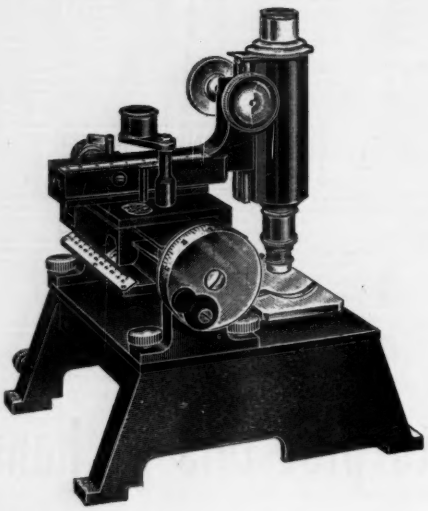

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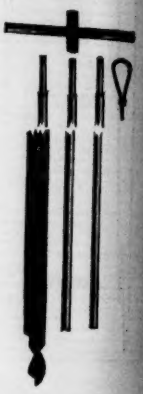

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